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INTELLIGENT CARGO USING INTERNET OF THINGS

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Abstract: In Supply Chain Management the transportation of perishable agricultural products effectively plays a vital role in the sustainability of the entire process.It is also to be noted that most of the post- harvest wastage occurs in the transportationphase. In this paper we propose a system to optimize the transportation of the perishable products. ALow Power Wireless Sensor Network using IPv6 (6LoWPAN) is used to monitor the physicaland environmental conditions like temperature,pressure,motion or pollutants thereby enabling these low power devices to be a part of the Internet of Things (IoT). The past learning experiences of the freightare incorporated to make appropriate decisions in order to enhance the profits earned by the supplier and also to satisfy the demands of the consumer by supplying the perishable products at the correct scale of freshness.

I. INTRODUCTION

The Internet of things is the foundation for connecting things like sensors, actuators and also the other smart objects which in turn enables person to person communication or object to object communication. The idea of IoT is that everything can be tracked and traced remotely. The concept of IoT is to make the machines and computers independent of people and try interpreting and manipulating data. The world comprises of many devices that are connected to each other. By the turn of the decade many more devices are said to be used. There is a necessity for these devices to be connected to each other. This service is provided by the internet. All information from the devices is exchanged via the internet. Quintillion amount of data is said to be exchanged every day and the amount is only said to increase day by day due to the increase in number of devices in the future. The IoT is used in various fields which include information technology,e-business,logistics and so on. It is also applicable in urban planning, healthcare, waste management, security and in monitoring traffic. Equipping all objects in the world with minuscule identifying devices or machine- readable identifiers could transform daily life. If all objects and people in daily life were equipped with identifiers, they could be managed and inventoried by computers. IPv6's huge increase in address space is an important factor in the development of the Internet of Things. From a conceptual standpoint, the IoT builds on three pillars, related to the ability of smart objects to: (i) be identifiable (anything identifies itself), (ii)to communicate (anything communicates) and (iii) to interact (anything interacts)– either among themselves, building networks of interconnected objects, or with end-users or other entities in the network. Developing technologies and solutions for enabling such a vision is the main challenge. [1] In general the IoT will need to support the features like device heterogeneity, scalability, localization and tracking capabilities, self-organization capabilities, data management and semantic interoperability, embedded security and privacy-preserving mechanisms. Supply chain management (SCM) is the management of the flow of goods. It includes the movement and storage of raw materials and finished goods from point of origin to point of consumption. It consists of interconnected or interlinked networks and channels which are involved in the delivery of products to the customers. It is estimated that 23%-25% of fruits and vegetables are lost post-harvest and that 25%–50% of the total economic value is lost because of reduced quality. There is $35B in annual global waste for perishable foods while about 50% is due to temperature variations.The UN's Food and Agriculture Organization said that an estimated 1.3 billion tons of food are wasted annually in the world where more than 800 million people are counted as chronically hungry or malnourished. According to the report, 54 percent of the world's food waste occurs during transportation.

II. BACKGROUND &RELATED WORK

Tracing the food products during transportation is of prime importance.Tracing can be done in two ways namely active and passive. The passive tracing method actually focusses on the position of the object at all times and disposition from that place. The information stated is that active tracing method keeps track of the online information in order to optimize and control process between the various phases of the supply chain. There are three basic objectives of tracing a product they are improving the supply chain management, differentiate between the products using quality as a measure and to provide functions to estimate the safety and quality of the product.Tracking the individual product and the distribution unit plays a major role in determining the efficiency of the traceability process. The physical traceability focuses on the actual tracking of the product whereas the qualitative traceability involves tracking the quality of the product. The food chain would require the key aspects of traceability to prevail.It is suggested that the traceability process can be used in order to find the quality of an edible item at various conditions which can also be used to prevent food spoilage .In this way this method ensures that both food safety and quality is maintained. [3] The information stated is that when barcode readers or the RFID tags are used it can determine only passive sense tracing and the quality of the product cannot be determined. Wireless Sensor Nodes are introduced to provide the two key aspects of traceability namely qualitative and physical traceability of a product. [3] In the system architecture of Internet of things (IoT) system four layers are present: object sensing layer, data exchange layer, information integration layer, and application service layer. The object sensing layer is concerned with sensing the objects and obtaining data. The data exchange layer handles an efficient and secure transmission of object data. The information integration layer processes the uncertain information acquired and transforms it into usable information. The application service layer provides specific content services based on the processed information for various users. The information is sensed from the object and the decisions are made accordingly.[4] Consumers are

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interested to know about the sustainability of the process involved during production and also the delivery of the product. It is necessary to develop information systems in order to know about the sustainability of a process and also to give frequent updates to the stakeholders. So information should be made transparent at different levels to both the customers as well as the decision makers.[5]Sustainability is defined as a situation in which the needs of the present generation are met without impeding on the satisfaction of needs of future generation. Transparency of a supply chain is the degree of shared understanding of and access to product related information as requested by a supply chain's stakeholders without loss or noise. The information stated is based on the fact that there are two dimensions for transparency namely horizontal and vertical.[5] The horizontal dimension focusses on the requirements of the respective companies at various stages of the supply chain and also regarding what information is to be made available to the stakeholders. The vertical dimension contains the requirements and legislation that apply to all the companies in a specific supply chain. Environmental impact can be regarded as a product quality dimension which however is not visible throughout the supply chain process. Internet can be used as a medium to exchange information between the various actors participating in the supply chain process to improve transparency and thereby to support sustainability.

III. Problem Definition and Motivation

Supply Chain Management consists of a number of phases in which the transportation plays an important role. The perishable products are to be delivered at the desirable quality in the right time. The problem that is addressed in this paper deals with optimal delivery of the goods either to the subwarehouse or to the shopping market. The lack of constant monitoring of the product during the freight contributes towards the food wastage during the transportation phase. The various factors that influence the freshness scale of the product which includes the natural and physical conditions are to be considered before the movement of the goods from the source to the destination. The collected data needs to be processed efficiently to make the right decisions.

IV. Proposed System Model

The system design consists of the sensors deployed inside the truck and the gateways which communicate to the monitoring center using the IEEE 802.15.4 standard as shown in Fig1.

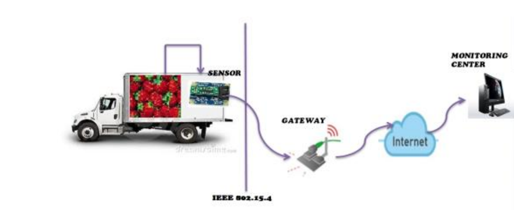

Fig.1 System model

The sensors are deployed inside the truck to monitor the freshness of the product. The values read by the sensors are sent to the monitoring system via IPV6 using Low power Wireless Personal Area Networks (6LoWPAN). The6LoWPAN group has defined encapsulation and header compression mechanisms that allow IPv6 packets to be sent to and received from over IEEE 802.15.4 based networks. Based on the values received from the gateways, the monitoring center makes appropriate decisions to optimize the journey.

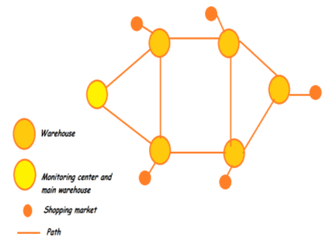

Fig 2.Graph model

The monitoring system is present in the main warehouse and many shopping markets are connected via sub warehouses. Initially an optimal route is provided to the truck driver through which the product is delivered to the market. During the freight if there is any change in the freshness level of the food product which is indicated by the sensors placed inside the truck, then the information is sent to the monitoring center. Based on the level of freshness of the product, it will be removed or delivered to the nearest shopping market.If the freshness level falls below the scale, the product is replaced in the nearest sub warehouse. The modification in the route is notified to the truck driver from the monitoring system. The entire system is represented as a graph in Fig.2.

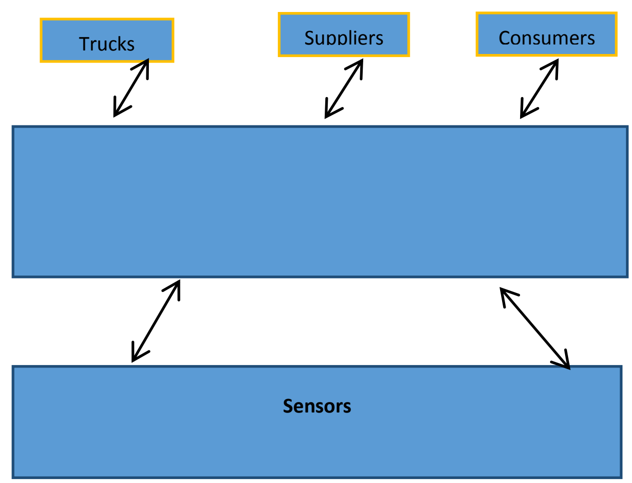

Fig.3 Functional Architecture

INFORMATION FLOW

The functional architecture of the proposed system is depicted in Fig3. The layer in the bottom includes the sensors where the condition of the product is sensed at frequent intervals. The data is sent to the gateway and then to the monitoring center. The second layer in the figure denotes the operations that are carried out in the monitoring center which includes finding the optimized path, optimizing

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the stock, tracking the vehicles and so on. The upper layer includes the truck drivers, suppliers, users. The information is revealed at different levels to the truck drivers, suppliers and users. The truck drivers will be provided with a route to deliver the products in the specified warehouse and if there is a change in the specified route due to fall in the freshness levels the change in freight will be intimated to the truck driver. The consumers will be provided with the freshness scale of the product.

V. IMPLEMENTATION DETAILS

A. Optimization of freight

The driver is provided with the optimized freight route depending on the current climatic conditions and also the past experience is taken into account.The route is suggested using the J48 decision tree algorithm. The sensors deployed in the truck will monitor the condition of the product and the values are sent to the monitoring center at regular intervals. When the values read fall below the specified levels, the truck is provided with the new route to the nearest warehouse in order to deliver the products at the nearby markets or to remove the decayed products from the truck so that the entire stock is not subjected to further decay. The K-NN algorithm is employed in order to find the nearest warehouse.

B. Sensor Information

Contiki is an open source operating system for networked, memory-constrained systems with a particular focus on low-power wireless Internet of Things devices.Contiki provides powerful low-power Internet communication.Contiki supports fully standard IPv6 and IPv4, along with the recent low-power wireless standard 6LoWPAN.Contiki can be freely used both in commercial and non-commercial systems and the full source code is available.The sensor data is simulated using the Cooja simulator as shown in Fig 4. Cooja simulates networks of Contiki nodes. Contiki applications are written in standard C. With the Cooja simulator Contiki networks can be emulated before burned into hardware, and instant Contiki provides an entire development environment in a single download. Cooja, the Contiki network simulator, makes this tremendously easier by providing a simulation environment that allows developers to both see their applications run in large-scale networks or in extreme detail on fully emulated hardware device. Several different Contiki libraries can be compiled and loaded in the Cooja simulation, representing different kinds of sensor nodes (motes). Cooja allows for saving and loading simulation configurations. A simulation configuration contains the simulated modes and mote types, etc. The Sensor values i.e., temperature and the humidity values are obtained by entering the address of the node in the Uniform Resource Locator (URL) as shown in Fig.5 Several different Contiki libraries can be compiled and loaded in the same Coojasimulation, representing different kinds of sensor nodes (heterogeneous networks). Coojacontrols and analyzes a Contiki system via a few functions. This approach gives the simulator full control of simulated systems.

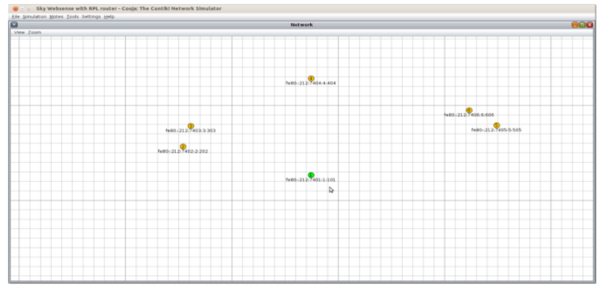

Fig. 4 Cooja Simulator

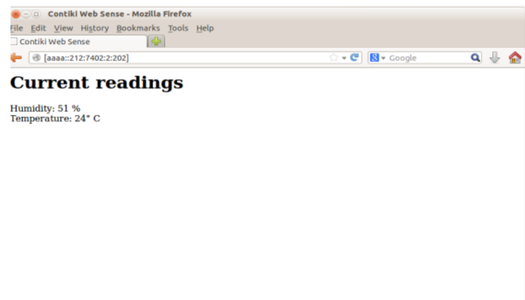

Fig.5 Sensor Reading Values

C. Vehicle Tracking

The source to destination route map is specified in Google Earth to define a route by using the "Add Path" tool in Google Earth. The user can use as many or as few waypoints as they want and can edit routes by moving, adding, or removing waypoints. The path is saved as a standard Google Earth KML file which is imported into simulator tool, which then fills in and soothes the trajectory between the waypoints.Simulations can be used to obtain the real time trajectories on a specific path. The latitude and the longitude values of the freight at particular intervals are filtered from the trajectories and are stored.

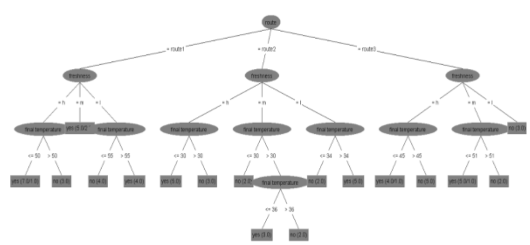

Fig 6.Intelligent Cargo Decision Tree

The decision tree generated in Fig 6 by J48 can be used for classification. J48 builds decision trees from a set of labeled training data using the concept of information entropy that is available in Weka. It uses the fact that each attribute of the data can be used to make a decision by splitting the data into smaller subsets. J48 examines the normalized information gain (difference in entropy) that results from choosing an attribute for splitting the data. To make the decision, the attribute with the highest normalized information gain is used. Then the algorithm recurs on the smaller subsets. The splitting procedure stops if all instances in a subset belong to the same class. Then a leaf node is created in the decision tree telling to choose that

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class. But it can also happen that none of the features give any information gain. In this case J48 creates a decision node higher up in the tree using the expected value of the class. J48 can handle both continuous and discrete attributes, training data with missing attribute values and attributes with differing costs. Further it provides an option for pruning trees after creation.The input to this algorithm will be the route, source, destination, season and also the freshness scale at which the product should be delivered. The output of the tree would determine whether the particular route can be taken or not. In K-NNclassification, the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors. K-NN is a type of instance-based learning, or lazy learning, where the function is only approximated locally and all computation is deferred until classification. The neighbors are taken from a set of objects for which the class or the object property value is known. This can be thought of as the training set for the algorithm, though no explicit training step is required. The training examples are vectors in a multidimensional feature space, each with a class label. The training phase of the algorithm consists only of storing the feature vectors and class labels of the training samples. In the classification phase, k is a user-defined constant, and an unlabeled vector (a query or test point) is classified by assigning the label which is most frequent among the k training samples nearest to that query point. A commonly used distance metric for continuous variables is Euclidean distance.

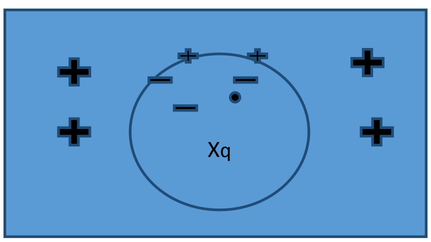

Fig7. K-NN Example

In Fig 7the value of k=5, the query instance is denoted by Xq which is compared with the other instances in the data which is denoted by plus and minus signs. Here since three of the neighbors near the query instance are negative Xq is also negative.

VI. PERFORMANCE EVALUATION

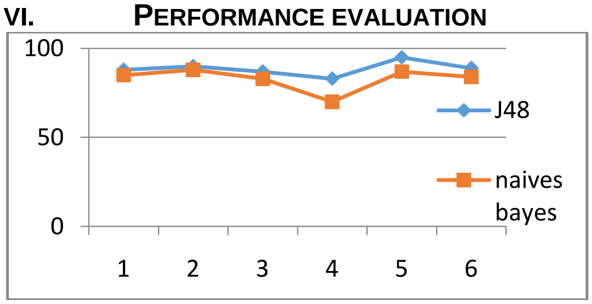

Fig 8. Decision Tree vs. Naive Bayes

This graph in Fig 8 plots the accuracies between the decision tree and naive Bayes algorithms. The x- axis represents the number of tuples in the training set and the y -axis represents the accuracy measures. The J48 algorithm provides more accurate results for the current training set than the naivesbayes algorithm.

VII. CONCLUSION

In this paper we have implemented an intelligent cargo system for efficient transportation of goods from a given source to destination. The sensors are simulated using Cooja and also the route map is visualized. The most preferential route is taken in order to effectively maintain the state of the product in the desirable state. The machine learning algorithms like decision tree, K-Nearest Neighbors are used to learn from the past experiences and decide on the best possible route to maintain the freshness of the products. We use a training set to learn and the results obtained from them are used to decide future predictions.These predictions are applied to a test set. In addition to finding the optimized route, the vehicles are tracked based on the GPS trajectories. Simulation is used to generate the trajectories of a route. As future work real time situations like traffic, truck breakdown and catastrophic effects can be considered in order to improve the results. Real time sensor data could be obtained using various routing protocols over the wireless medium.

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