Asian Agricultural Research 2013, 5(5): 148 – 150

Information Collection System of Crop Growth Environment Based on the Internet of Things

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Abstract Based on the technology of Internet of things, for the issues of large amount data acquisition and difficult real time transport in the data acquisition of crop growth environment, this paper designs one information collection system for crop growth environment. Utilizing the range free location mechanism which defines the node position and GEAR routing mechanism give solutions to the problems of node location, routing protocol applications and so on. This system can realize accurate and automatic real time collection, aggregation and transmission of crop growth environment information, and can achieve the automation of agricultural production, to the maximum extent.

Key words The Internet of things, Node mechanism, Routing mechanism

1 Introduction

The Internet of things, IOT for short, is the third wave of information industry following the computer and Internet. IOT integrates sensor technology, embedded computer technology, distributed information processing technology, modern network, wireless communication technology and so on, which is able to monitor and collect the information of various objects under test in real time with the collaboration of various types of integrated micro sensors. The information is sent wirelessly and transmitted to user client through ad hoc multi-hop network, thereby achieving the connection of physical world, computer world and human society. The crop growth environment information is mainly acquired through manual measurement in traditional agriculture. With the continuous development of IOT, the use of wireless sensors makes it possible to reduce labor consumption and influence on farmland environment, and thus acquire accurate crop growth environment data. The deployed wireless sensors may observe the living habitat, environment, physiological status and population complexity of livestock, poultry and aquatic animals, and may be used for monitoring forest environment and fire alarm. In various control systems, temperature sensor, humidity sensor, pH value sensor, light sensor, ion sensor, biosensor, CO_2 sensor and other devices in the IOT system detect physical parameters such as temperature, relative humidity, pH value, light intensity, soil nutrient, CO_2 concentration which are displayed through various instruments in real time or as parameters of automatic control to take part in automatic control to ensure a favorable and suitable environment for crops.

2 The design of crop growth environment information collection system

By placing sensors of different functions in the area to test, climate changes including temperature, humidity, water and other crop growth environment information are being monitored. Based on crop growth needs, changes must be made to help with the disaster prevention and reduction as well as scientific farming. This system can reduce manual operations and error in manual measurement in actual production process to decrease the cost of agricultural production. Besides, the system can realize real time collection, aggregation and transmission of crop growth environment information as well as the automatic operation of agricultural production to the maximum extent. The agricultural managerial personnel can get real time information and advices on agricultural production and disasters, and thereby respond and make adjustment.

Depending on specific circumstances, the system uses soil water sensor, wind velocity and direction sensor, barometric pressure sensor and ambient humidity sensor as network nodes to monitor the temperature, humidity, soil moisture, barometric pressure, wind velocity and direction of crop growth environment to achieve the comprehensive monitoring of relevant environment parameters and crop growth status, and to realize the timely forecast of environment information to be processed.

Based on full considerations on the features of IOT, this research simplifies the architecture and focuses on the design of system structure, routing protocol and node location algorithm. The system mainly comprises of sensor nodes, cluster head nodes, aggregation nodes and task management nodes. The system structure is shown as follows:

3 Crop growth environment information collection system features

Sensor nodes in the system are used to acquire crop growth environment information. Sensor nodes deployed in the monitoring area make up basic units of IOT. Sensor nodes which through ad hoc form the node network can communicate to each other. Adjacent nodes in the network generate a cluster. A cluster head node collects the information each node in the same cluster acquires and then after data fusion sends the compressed data to an aggregation

Received: January 20, 2013 Accepted: April 14, 2013
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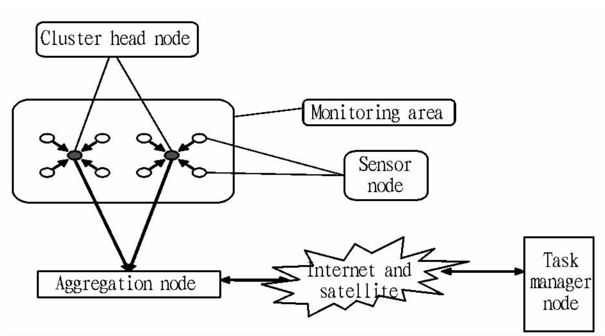

Fig. 1 Architecture for crop growth environment information collection system

node.

An aggregation node takes charge of communication tasks between task management nodes and sensor nodes. Generally, an aggregation node is one more energetic sensor node or a router with wireless gateway function.

Task management nodes are management center of WSN data and commands, generally made up of several servers. With task management nodes, users configurate and manage the sensor network, post monitoring tasks and collect monitoring data. Task management nodes can analyze and store the acquired information, and can also post commands to sensor nodes in real time.

The sensor nodes in monitoring area can be located by GPS or node self-localization algorithm. Sensor nodes collect information according to the commands sent by task management nodes and send acquired data to cluster head nodes which converge the data before sending it to corresponding aggregation nodes. Aggregation nodes will receive the data and after data filtering and sorting transmit it to task management nodes through Internet or communication satellite.

4 Information collection system workflow

Fig. 2 shows the workflow of crop growth environment information collection system.

(i) The user send a request command through a task management node for the inquiry of the indicators of crop growth environment information and then the command is transmitted to the aggregation node by Internet and ZigBee.

(ii) The aggregation node selects the cluster to be inquired according to the specific requirements of the request command. After receiving the command the cluster head awakes and activates all the nodes within cluster to acquire and store data and communicate. Nodes collect data in time according to the command requirements and after digital-to-analogue conversion send the data to corresponding cluster head node. The cluster head node converges all the data received and send the converged data back to the aggregation node.

(iii) The aggregation node filters and sorts the received data before sending it to the task management node by external network. The task management node feedbacks the collected data to the user and simultaneous stores the data in crop growth environment information database for future use.

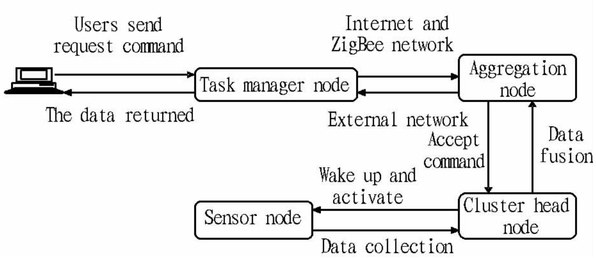

Fig. 2 Workflow for crop growth environment collection system

5 Routing mechanism

The key function of routing protocol is seeking for the optimization of route between the origin node and the destination node, and correct forwarding packet and transmit data along the optimized route. Among numerous routing protocols, geographic location routing is one of the most effective solutions for the energy and processing resource severely restrained WSN network. In these routing protocols, sensor nodes are divided into a few clusters to head of which the monitoring data of sensor nodes is transmitted. Cluster heads can converge the sample data and then transmit it to the Sink node to reduce the network flow.

The significance of timely getting the nodes' location information is to know the growing demands of crops more timely and accurately, and to improve the growth environment, aiming the high quality and yield of crops. Therefore, this system adopts GEAR (geographical and energy aware routing) routing mechanism, one kind of geographical location routing. GEAR routing assumes the location information of event area is already known and each node knows the location information as well as residual energy information of its own and all adjacent nodes. When the inquiry information reaches the event area, GEAR routing uses actual cost and estimated cost to express route cost. Estimated cost is calculated by the equation below:

$$c(N,R) = ad(N,R) + (1-a)e(N)$$

where $c(N,R)$ is the estimated cost from node N to event area R, $d(N,R)$ is the distance between node N and event area R, $e(N)$ is the residual energy of node N, and a is the scaling parameter. Greedy algorithm is used during the route creation. The node selects from adjacent nodes the node which has the minimum cost to the time area as next hop node and sets its own routing cost as the routing cost of next hop node plus the cost of one hop communication from this node.

When the inquiry command reaches the event area, iterative geographic forwarding strategy is used as one effective method to handle with denser crop growth environment information detection sensors. The node first receives the inquiry command in the event area divides the event area into several subareas and forwards inquiry command to the central positions of all subareas. In each subarea, the node most close to the center receives the inquiry command and again divides the subarea into several subareas and forwards inquiry command to central nodes. When the forwarding process in all subareas completes, the whole iteration process is over.

The greedy algorithm used by GEAR routing is a local optimal algorithm. For the known location information of node and adjacent nodes, GEAR routing can reduce greatly the probability of routing void, suitable for the application environment of fixed geographic locations or less frequent changes resembling the crop environment growth information collection network.

6 Node location mechanism

Data with no location information is hardly of any value. If the crop growth conditions in the monitoring area are not good, deficient fertilizer for example, which needs to be improved, then the accurate location of the sensor that has detected lack of fertilizer must be known. Only when combined with the node's location in the measurement coordinate, can the data collected by the node make sense. Therefore, the nodes should be located accurately in IOT. GPS is the simplest location method, which is of high precision, good instantaneity, strong anti-inference while high cost and demanding, making itself more suitable for self-organized sensor network of large scale and high cost. In accordance with the basic requirements of crop growth environment information collection system, this system utilizes the range free location mechanism to define node positions. This algorithm is of lower hardware requirements, less energy consumption and low cost.

The basic idea of this algorithm makes full use of redundant information from each beacon node to obtain the position of unknown node based on the inaccurate distance estimation method. Location is realized in 3 phases:

First all beacon nodes send 0 hop packets containing their own location data to adjacent nodes in the network, the receiving node ignores larger hops from the same beacon node and records minimum hops only, then forwards the hops plus 1 to other adjacent nodes and so on, making each unknown node gets the location data of each beacon node as well as the minimum hops from the node to beacon node; unknown node calculates the actual distance of average per-hop through the following equation based on the received unknown information of other beacon nodes and minimum hops, then posts the information:

$$Hopsizei = \frac{\sum_{j\neq i} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{j\neq i} h_j}$$

where (x_i, y_i), (x_j, y_j) are the coordinates of beacon node i and j respectively; h_j is the minimum hops between beacon node i and $j(i\neq j)$.

At last multiplying the intermediate hops of unknown node and reference beacon node by the actual distance of each per-hop figures out the estimated distance from the node to each reference node. The coordinate of unknown node can be acquired through trilateration. Range free location method can overcome the difficulties for other methods like high wireless sensor node requirements, high hardware cost and high energy consumption, to achieve more accurate location for unknown node, thus meeting the requirements of crop growth environment information collection system.

7 Conclusions

As part of a new generation information technology the Internet of things is applied in data acquisition, transmission and processing as well as task management and other aspects. IOT provides a new method to get and to process information. Focusing on the feature of large amount acquisition data in crop growth environment information collection system, combining with the advantages of IOT, this paper designs a crop growth environment information collection system based on IOT. The advantages of this design are as follows: (i) Energy saving. The use of GEAR routing mechanism and range free location algorithm avoids the energy consumption in self-organized network calculation for the node, thereby extends the service life. Meanwhile the application of geographic location routing can locate the crop position more precisely. (ii) Practical. This design is arranged according to the crop growth environment conditions in the area to test, presets sensor nodes and generates clusters, at the same time defines cluster heads of corresponding clusters for more efficient work. It is very flexible and practical.

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