Research on the smart wireless sensor perception system and its application based on Internet of Things

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Abstract

In order to solve the uncertain perception information appears in the perception process of intelligent wireless sensor, this paper considers the intelligent perception problem of Internet of Things (IoT) based on context perception. The current status of the research on intelligent perception and its existing problem is analyzed, and then a context perception method to solve the intelligent perception problem of Internet of Thing is proposed. The intelligent perception context description model of Internet of Things is constructed. In addition, it was investigated that how the intelligent routing maintained under fault conditions, and intelligent information management system of agriculture's was proposed of agricultural IoT system, combined with agricultural automatic control devices, which had already been successfully used in the agricultural production.

Keywords: Internet of Things, intelligent perception, automatic control, context perception, intelligent wireless sensor

1 Introduction

In recent years, the Internet of Things (IoT) as an international research hotspot, have obtained broad attention. It's represents the future trend of development of the network, and requires sharing interoperability and information, so as to realize human society, the information space, the physical world ternary comprehensive connectivity and integration as the goal. Therefore, the Internet of things is regarded as the third technological revolution in information field.

Sensing technology is an important part of the field of computer science and control science, for every object to implement networking of IOT environment "can be addressed; every object network can control [1]; every spatial networking can be communication" goal, sensing technology needs formatting commands from the past context-aware simple development to the natural perception of all-round [2], three-dimensional, modes of perception from a single man-machine perception extended to man, machine, material ternary world interaction mode. Therefore, research on key technology of intelligent sensing network environment, effectively solve the problem of environment perception of things, the realization of the human society, the information space, the physical world ternary has important theoretical significance and urgent reality needs.

Over the past decade, studies carried out by China in the field of agriculture IOT technology covers the use of agricultural resources [3], agricultural ecological environment monitoring, fine management of agricultural production, agricultural product quality safety management and traceability, and other fields, but basically is at the start stage [4]. The IOT in the utilization of agricultural natural resources monitoring, based on the GPS land management and farmland information acquisition and positioning technology [1], the wireless sensor network, mobile communication network and information transmission and so on, to carry out agricultural resources network investigation of agricultural ecological environment monitoring aspect, carried out the research of soil moisture monitoring combined with ground stations and remote sensing technology based on the developed, atmospheric environment and water environment monitoring system; agricultural production of fine management [5], to carry out agricultural bio - environment information acquisition system, developed intelligent monitoring system for orchard production facilities [6]; development of livestock and poultry, aquaculture network monitoring system; developed agricultural management and traceability of the quality and safety of agricultural products [7], agricultural produce real-time information collection and transmission technology, application evaluation system and agricultural produce secure digital early warning model; electronic tag information classification and coding rules, the development of agricultural and rural consumer goods circulation regulatory information service system [8].

To sum up, agricultural IOT technology includes not only digital agriculture sensing technology, but also including wireless agricultural information network

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transmission technology; it is the reverse of the traditional agricultural practices, conservation of resources, and the importance of environmental protection scientific means, the main direction of the future development of agriculture. This topic using context-aware intelligent perception of key technology on the theoretical calculation of network environment, analysis of the current status of intelligent perception and the existing problems, put forward an intelligent sensing architecture based on context awareness, conducted in-depth study and on the interaction context perception, expression, fusion model and algorithm of the basic problem.

2 Intelligent perception and architecture of IoT environment

Agriculture of IoT consists of three layers: that is the farmland information perception layer, information transmission layer and application layer system. The first layer is the information perception layer, including the RFID barcode, sensors and other equipment, can achieve real-time information, dynamic perception, recognition and information acquisition, perception layer mainly consists of farmland environment information collection, soil information, plant nutrition and physiological information; the second level is the information transmission layer, can realize remote wireless transmission from the Internet data information, it is mainly reflected the farmland information acquisition and transmission of large scale in the agriculture of Things [9]; the third level is the application of information system, the system can provide intelligent agriculture management by controlling the data processing and intelligent management, agricultural automation equipment, combined with the realization of intelligent agricultural production and information management, to achieve the target of save resources, protect environment and improve product quality and yield of agricultural production. Three levels of agricultural network were given an IOT to overall perception information, data transmission reliability; optimize system and intelligent information processing characteristics. Agricultural technology three levels as shown in figure 1.

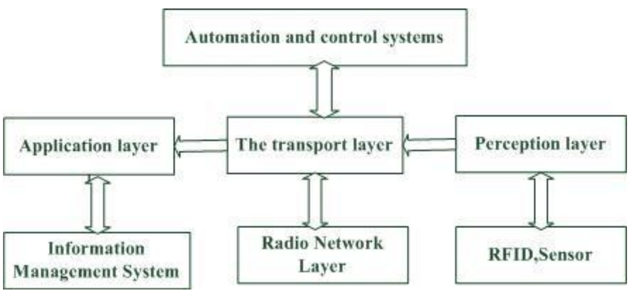

FIGURE 1 Three levels of Agricultural IOT

Intelligent perception system of IoT supports intelligent interaction the ternary of the world among of the people, machines and materials. This new type of interactive system makes the traditional IntelliSense system will face unprecedented new problems and challenges. The Internet of things to achieve the ternary world of human society, physical world, information space comprehensive connectivity and integration, it allows anyone to interaction anything at any time and any place to use any network and any service interaction.

In the IoT environment, various sensors, radio frequency identification technology, infrared sensing, global positioning system and other information generating apparatus coexist, and complex association. The user input is no longer the only trigger a system's driving force, in the IoT environment, even if the user does not sends service request, all kinds of "physical interaction" can also trigger system of intelligent computing services. In order to achieve this goal, we propose to implement the intelligent interactive system networking environment by using the context-aware technology. In this system, in addition to the user input, equipment, people, systems in various connected depending on the context interact, thus it can be seen, the networking environment context contains not only the user, system related information collection ,but also contains a collection of related information objects.

In view of the above problems, we propose the intelligent sensing architecture for Internet of things based on the context, as shown in figure 2. In this architecture, users and objects interact through the architecture of the intelligent sensing system. Where the object is divided into general devices and smart object class two, general equipment refers to the physical equipment can be identified single, one-way only provide environmental parameters for the system, intelligent objects can be perceived and physical equipment intelligent control. The technical framework of fusion rules to realize context, such as the environment changes, we only need to modify the corresponding rules without the need to modify the program code can adapt to these changes, thus increasing the intelligent interactive system adaptability.

3 Context-aware method of IoT

The context fusion method of IOT commonly used Bayesian estimation method and the Bayesian estimation method, neural networks and fuzzy inference, the following description these fusion methods.

3.1 BAYESIAN METHOD

The basic principle of the Bayesian approach is: given prior likelihood estimation, if we add an evidence (measurement), can be on the front (about the target attribute) likelihood estimation to be updated [10]. That is to say, with the measured value is coming, can be given assuming a priori density update for the posterior density. If $A_1, A_2, \ldots, A_n$ representation n exhaustive incompatible assumptions (i.e. the presence of a target having the properties i), B is a event (or facts and observations), then the Bayesian formula is given by

$$P(A_i|B) = \frac{P(B|A_i)P(A_i)}{\sum_{j=1}^{n} P(B|A_j)P(A_j)}, \quad (1)$$

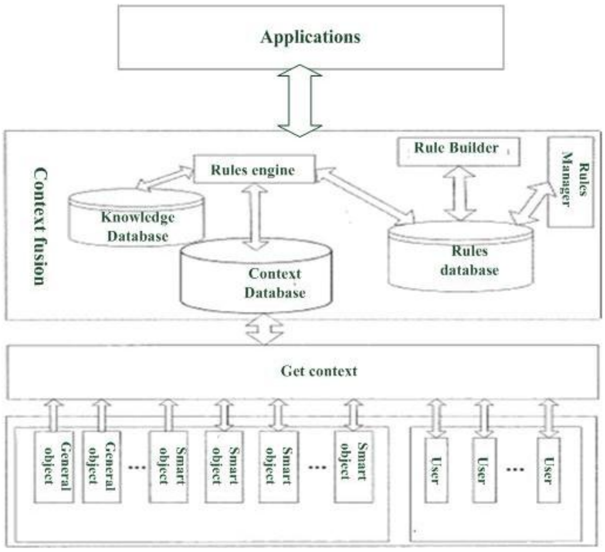

FIGURE 2 A typical electric power network

and satisfies conditions $\sum_{i=1}^{n} P(A_i) = 1$,

$\sum_{i=1}^{n} P(B|A_i)P(A_i) = \sum_{i=1}^{n} P(B, A_i) = P(B)$,

where $P(A_i)$ is the appears possibility of events $A_1, A_2, \ldots, A_n$, and is a priori probability at assuming Ai is true condition, which is the known fact that before the experiment; $P(A_i|B)$ is given evidence of B (i target exists) conditions, assuming that A_i is true posterior probability, $P(B|A_i)$ is true condition observed probability of evidence B given A_i, $P(B)$ is the a priori distribution density of B.

Bayesian inference method to context data can be collected on the IoT Setting intelligent interactive system in multi-sensor devices and smart body fusion [11]; given assumptions to calculate the posterior probability is true. Set n sensors (they may be a different matter) work together on a target detection, set goals m attributes need to identify both of m hypotheses or propositions A_i $(i = 1, 2, m)$. Bayesian fusion algorithm to achieve multiple stages carried out. The first step is the collected data according to their context information obtained characteristics to identify the target attribute contact classification; the final target property is given a description of $B_1, B_2, \ldots, B_n$. The second step is calculated for each sensor (evidence) in all assumptions true condition of the likelihood function. The third step is collecting more evidence is assumed to be true posterior probability based on Bayesian formula. The final step is the decision logic, to generate the attribute determination conclusions. The process is shown in figure 3.

In the third step, the fusion probability calculation of the target identity can be divided into two steps.

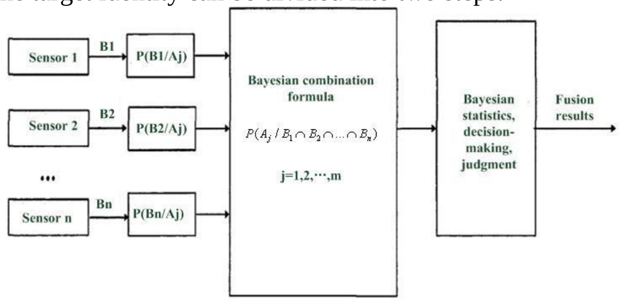

FIGURE 3 Bayes reasoning based data fusion

First, calculate the joint likelihood function of n evidence for the hypothesis under the condition of A_i, when each sensor or smart independent detection, $B_1, B_2, \ldots, B_n$ is independent of each other, the joint likelihood function is given by:

$$P(B_1, B_2, \ldots, B_n|A_j) = P(B_1|A_j)P(B_2|A_j)..P(B_n|A_j). \quad (2)$$

Then, using the Bayesian formula is obtained the posterior probability under the condition of n evidence, so we can write

$$P(A_j|B_1, B_2, \ldots, B_n) = \frac{P(B_1, B_2, \ldots, B_n|A_j)P(A_j)}{P(B_1, B_2, \ldots, B_n)}. \quad (3)$$

The main advantages of Bayesian approach is axiomatic basis and mathematical properties of easy to understand, and only needs to calculate time medium.

3.2 NEURAL NETWORK METHOD

The neural network is to emulate the biometric information processing system for flexible information processing capability [12]. It is a microscopic simulation of the human brain function; microscopic numerical model is distributed neural network learning through a large number of samples of experience, expert knowledge and diagnosis example in the form of distribution of the weights and the closing value within the network, and the use of neural network retention to complete uncertainty reasoning. More importantly, the neural network has a strong self-learning capability, using a specific neural network learning algorithm to obtain knowledge uncertainty reasoning mechanism.

In the neural network model, radial basis function (RBF-Redial Basis Function) neural network is more representative of the meaning, it is a kind of neural network model proposed by J.Moody and C.Darken in the 80's of the last century [13], is composed of input layer, a hidden layer (radial base) and a linear output layer prior to the neural network, RBF neural network is the main feature of hidden layer radial basis function as the activation function of neurons, it has the characteristics of local experience [14], radial basis function has many forms, including the Gauss function is used more often in a radial basis function. Figure 4 shows the radial basis function neurons with n input nodes.

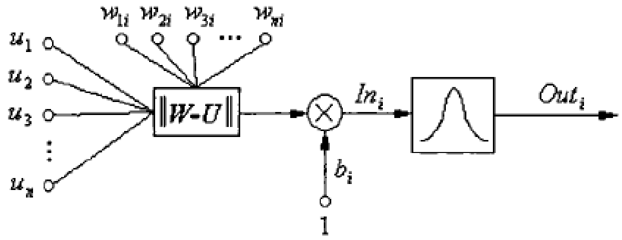

FIGURE 4 Radial basis function neurons with n input nodes

Figure 4 shows the hidden layer neurons is the vector distance between the deviation bi layer of the weight vector w and the input vector u multiplied as the input of the neuron activation function. So we can write

$$In_i = \left(\|w-u\|.b_i\right)^2 = \sqrt{\sum_{j=1}^{n}\left(w_{ji}-u_j\right)^2.b_i} \ . \tag{4}$$

If we take the radial basis function is a Gaussian function, so we can write output neurons is

$$Out_i = e^{-\ln_i^2} = e^{-\left(\|w-u\|.b_i\right)^2} = e^{-\left(\sqrt{\sum\left(w_{ji}-u_j\right)^2.b_i}\right)^2} \ . \tag{5}$$

By formula (4) can be seen, along with the decrease of distance between W and u, the radial basis function output value increases, and when the input is 0, which is between the W and the U distance is 0, the maximum output value is 1. Therefore, radial basis neurons as an output of one detector at the same time output of the input vector and its weight.

The radial deviation grassroots B can be used to adjust the sensitivity of the basis function, but in practical applications, more direct use is another called the stretch parameters constant two. It is used to determine each radial primary neuron to the input vector, which is the width of the radial basis function between the U and the w distance of the corresponding. Value σ (or B value) in practical applications there are many way to determine.

4 Agricultural IoT architecture and performance evaluation algorithm

4.1 AGRICULTURAL IOT ARCHITECTURE

Agriculture of Things the basic structure shown in Figure 5, the wireless sensor network architecture shown in figure 6, usually including a sensor node, a sink and a management node. Research on networking agriculture was the main star network topology.

Agricultural fertilizer and water management, the principle is similar to spraying management and automatic irrigation. Automatic irrigation system is a complex control system, their input variable is not only the water content of the soil, but there is still time, temperature, humidity, crop varieties, and crop growing season. The traditional automatic irrigation is generally the timing or timing procedures manipulation when to begin irrigation, irrigation and more often based on the experience of people for a long time may be. Soil moisture sensor control device as an automatic irrigation system, you can do the crop needs water supply, you can automatically open water, began to spray irrigation, to achieve timely sprinkler irrigation, water-saving.

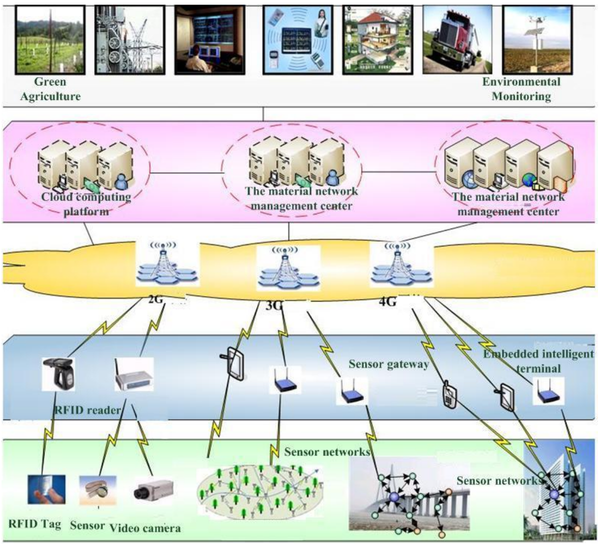

FIGURE 5 Agriculture of IOT structure

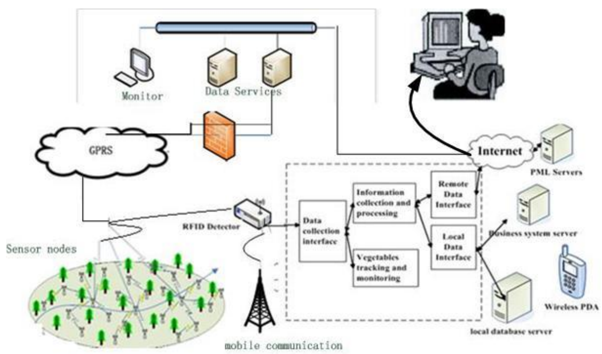

FIGURE 6 Communication basic system structure of networking

This paper focuses on the control method of automatic irrigation network information. To realize the automatic control of irrigation water, first with the real-time dynamic information acquisition field soils, in obtaining water information can be based on a variety of automatic control mode to implement the automatic irrigation. Implementation of automatic irrigation principle diagram as shown in Figure 7.

Farmland irrigation control has three control modes that are regular irrigation, automatic control and manual control. Timing irrigation is widely used, especially for the larger significance of soilless cultivation. Manual control is mainly left to the user need to manually provide manual control function, in this study, the use of manual control valve must be preset before the time limit. The diagram of information collecting node in plantation is shown in figure 8.

4.2 THE AGRICULTURE OF IOT INFORMATION COLLECTION AND TRANSMISSION OF TECHNICAL INDICATORS

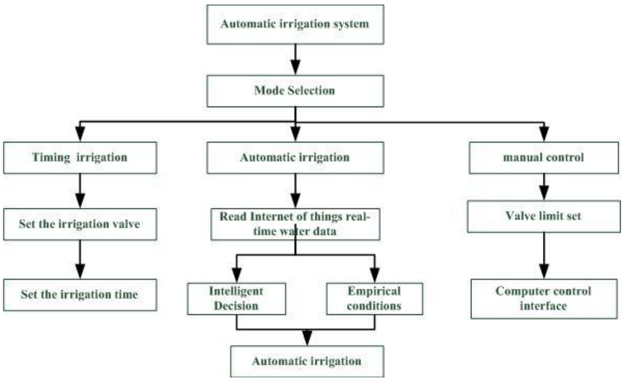

FIGURE 7 The agriculture of IOT and transmission construction

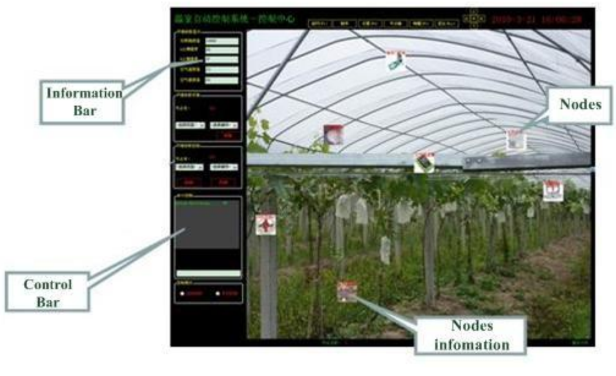

FIGURE 8 The diagram of information collecting node in plantation

Comprehensive evaluation index of IoT, according to the definition of the IOT network path, that is the assembly sequence is a $P(v_s, v_d)$ path in the G side, v_s is the source node, v_d is the destination node v_s from the source node to the destination node path v_d and is given by

$$P(v_s, v_d) = (v_s, v_1),(v_1, v_2),(v_2, v_3),\ldots,(v_{i-1}, v_i)\ldots(v_n, v_d). \qquad (6)$$

Also can be a collection of nodes to represent a path simplify represented as:

$$P(v_s, v_d) = v_s, v_1, v_1, v_2, v_2, v_3, \ldots, v_i \ldots v_n, v_d. \qquad (7)$$

For any one path $P(v_s, v_d)$ can define the consolidated network performance. The index contains a variety of attributes as a result of different applications, in which only consider the actual demand indicators, delay, bandwidth, and packet loss rate.

4.3 IOT NETWORK COMPREHENSIVE EVALUATION INDEX CALCULATION

IOT network performance indicators related to the average delay is $\overline{Delay}$, average bandwidth is $\overline{bandwidth}$, the average packet loss rate is $\overline{p-loss}$, the average network energy consumption evaluation is $\overline{PALL}$. However, a path of IOT road performance indicators and not fully representative of the network performance, and therefore proposed two different aspects of network comprehensive evaluation index, that is Q_oS_{dp} and Q_oS_{EB}. Propose network-wide indicators are Q_os, Q_os as a comprehensive indicator to measure the performance of the entire network situation. Where $\overline{Delay}$, $\overline{bandwidth}$, $\overline{p-loss}$ and $\overline{PALL}$ are given by

$$\overline{p-loss} = \frac{\sum_{i=1}^{m} p-loss(p(v_{si}v_{di}))}{m}, \qquad (8)$$

$$\overline{Delay} = \frac{\sum_{i=1}^{m} Delay(p(v_{si}v_{di}))}{m}, \qquad (9)$$

$$\overline{PALL} = \frac{\sum_{i=1}^{m} PALL(p(v_{si}v_{di}))}{m}, \qquad (10)$$

$$\overline{bandwidth} = \frac{\sum_{i=1}^{m} bandwidth(p(v_{si}v_{di}))}{m}, \qquad (11)$$

For a given source node and the destination node $S_d \in S$, a path $P(v_s, v_d)$ corresponding indicators following relationship:

$$Delay(p(v_s, v_d)) = \sum delay(v) + \sum Delay(e), v, e \in p(v_s, v_d), \quad (12)$$

$$Bandwidth(p(v_s, v_d)) = \min\{Bandwidth(e) + Bandwidth(v)\}, v, e \in p(v_s, v_s), \quad (13)$$

$$p-loss(p(v_s, v_d)) = 1 - \prod (1 - p - loss(e) - loss(v)), v, e \in p(v_s, v_d). \quad (14)$$

In order to specific application behind the accurately reflect and express the network performance as far as possible, the cumulative index of the network application on every path average and network tolerance compared to define comprehensive index, index of the network are often based on applications not difficult to form a fixed standard.

$$Q_oS_{DP}(p(v_s, v_d)) = \frac{\sum_{i=1}^{m} Delay(p(v_{si}, v_{di}))}{m \cdot Delay\_max} \times \frac{\sum_{i=1}^{m} p = loss(p(v_{si}, v_{di}))}{m \cdot p\_loss\_max}, \quad (15)$$

$$Q_oS_{EB}(p(v_s, v_d)) = \frac{\sum_{i=1}^{m} bandwidth(p(v_{si}, v_{di}))}{m \cdot bandwidth\_max} \times \frac{\sum_{i=1}^{m} PALL(p(v_{si}, v_{di}))}{m \cdot PALL\_max}, \quad (16)$$

$$Q_oS(P(v_s, v_d)) = Q_oS_{EB}(p(v_s, v_d)) \cdot Q_oS_{DP}(p(v_s, v_d)), \quad (17)$$

where $Delay\_max$ specify a limit on the maximum tolerable delay for the network, p_loss_max specify the upper limit of the most tolerant of packet loss rate for the network specified maximum tolerated, the $bandwidth\_max$ is the network specified maximum tolerance bandwidth usage limit. $PALL\_max$ specify the maximum tolerable energy consumption for the network upper limit value.

4.4 IOT NETWORK PERFORMANCE TEST

Place the sensor nodes in the test of farmland large-scale farmland in 100m*600m, according to the characteristics of the actual field information collection, information acquisition and routing process the scene. The following concrete experimental plan:

In the experimental area, all the sensor nodes will transmit power amplification coefficient tune 0, signal wireless transmission distance will be significantly shortened. The test is divided into two parts, the part of the network node free networking. Test networking performance in three modes, namely: the shortest path Experimental Test (SPET), shortest path and competition for resources to optimize network the networking performance testing (O-SPET) and the depth of routing protection (D-SPET) network performance testing.

The average bandwidth occupied in three network modes experimental data as presented in Table 1, the average network delay in three network modes experimental data as presented in Table2, the average packet loss rate of the network of three nodes experimental data as presented in Table3 and the average energy consumption in three network modes experimental data as presented in Table4.

Figure 9, 10, 11, 12 respectively is the network performance test results of three kinds of network mode. Set the $Delay\_max = 6$, $p\_loss\_max = 3\%$, $PALL\_max = 30$, $bandwidth\_max = 40$. The test results show that the shortest path (SPET) network has the worst performance, the $Q_oS = 1.21$, and the O-SPET's $Q_oS = 0.15$, compared to D-SPET's $Q_oS = 0.26$, network delay of both are similar, but the O-SPET than the D-SPET packet loss rate is low; the energy consumption is lower than that of O-SPET and D-SPET. It can be selected according to the actual situation in two different ways in different applications, routing network to improve the way. If you installed the Internet of Things adequate energy consumption on the premise, you can choose the O-SPET optimization method.

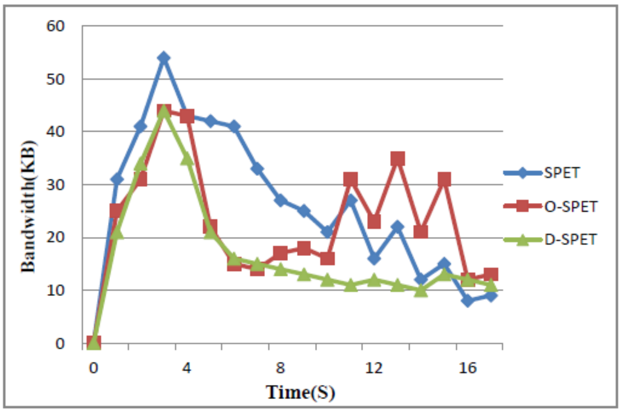

FIGURE 9 Average bandwidth occupied in three network modes

5 Conclusions

This paper proposes the use of context-sensitive technology to achieve intelligent interactive environment of IoT. IoT environment intelligent interaction throughout the entire space of human activities, any legitimate user can at any place, any time, any computing resources and services, low-cost access. People do not need to care about the specific means to achieve the calculation, they do not care about the form in which computing and services, so that humans can achieve the status of "wisdom" more refined and dynamic management of production and life, improve resource utilization and productivity levels. To presents the shortest path method, depth of prevention and resource competition law in network optimization method. Studied agricultural IOT and automatic control system combining agricultural information and automation system architecture, development the agricultural intelligent control system, intelligent management of agricultural production park automatic irrigation, fertilizer and water management, and automatic spraying; achieve the intelligent the greenhouse full-parameter intelligent control; monitoring and intelligent management of aquaculture. Some examples of successful application indicate that the intelligent control system has good application prospects.

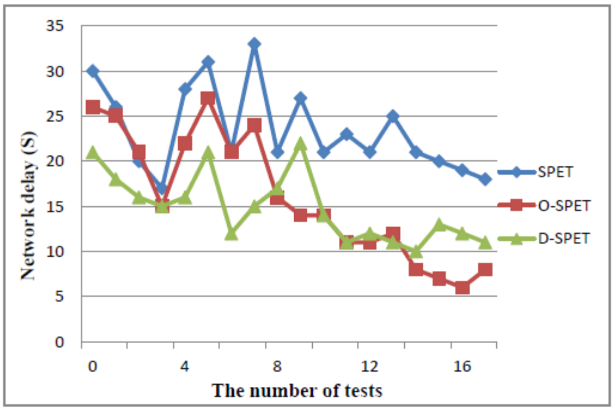

FIGURE 10 Average network delay in three network modes

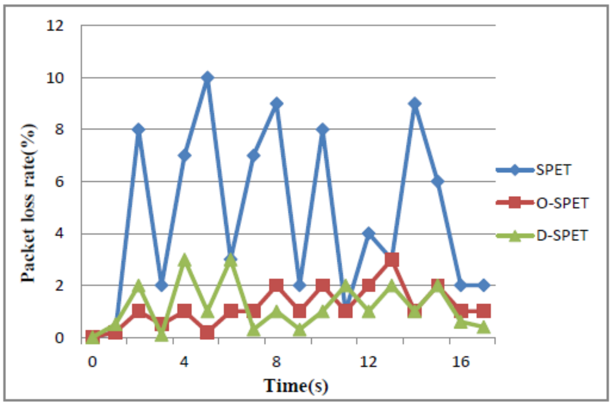

FIGURE 11 Average Packet loss rate of the network of three nodes

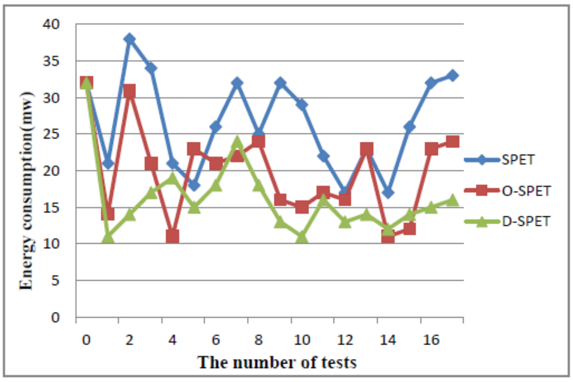

FIGURE 12 Average energy consumption in three network modes

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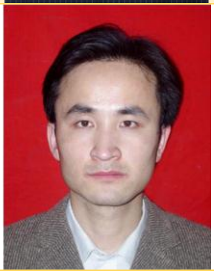

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