Study on Sensor Network Spectrum Detection Technology based on Internet of Things

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Abstract—In this paper, we conduct theoretical analysis and numerical simulation on the sensor network spectrum detection technology based on Internet of Things. In the field of Internet of things, information service system as a means of information, intellectualized, is an important research direction. In structure, Internet information service system is mainly composed of persistent database. Wireless sensor network foot a composed of a set of information collection, processing, and wireless transmission in the integration of wireless self-organizing network composed of micro sensor nodes. Sensor nodes structure will be designed according to different application scenarios, the structure of the wireless sensor network node is used to describe the different periods and different types of sensor nodes. If the realization of cognitive radio technology in wireless sensor network, not only can alleviate the congestion of public frequency band, and reduce the work frequency of the wireless sensor network also makes the node after single jump coverage is wide and change.

Keywords- Internet of Things; Sensor Network; Spectrum Detection; Cloud Computing; Topology Optimization

I. INTRODUCTION

Internet of things technology as a new thing, clear worldwide unified international standard has not been formed. Internet is a communication network and it can be common to find addresses of physical objects. The network is based on the Internet and other traditional telecom can carry information network [1]. For ordinary object to the device, the homemade terminals interconnected and intelligent is over the normal service of three main characteristics of it. Although the international standard on the Internet of things has not been formed, but fundamentally, the Internet of things technology is a technology, is a kind of polymerized application of ascension, this promotion is in the development of information technology to a certain degree [2]. Internet of things through will include artificial intelligence technology, modern network technology, sensing technology and other technology to gather combination, to reach the dialogue of people and things, formed a whole new world.

In the field of Internet of things, information service system as a means of information, intellectualized, is an important research direction. In structure, Internet information service system is mainly composed of persistent database, data interface, service operations and security mechanism and sharing mechanism parts [3]. On the mentioned Internet information service function, system target is Internet data storage and management, support information processing, and can realize data sharing between different Internet applications. Broad sense, the Internet of things is the communication system of any time, any place and the connection method of anyone, extended to connect any items. Namely, to establish the people and things, people, things and things, freedom of information exchange between each object is an information terminal, to form more complex system.

There are lots of related researches on the development of the Internet of Things. In [4], Perera's research group conducted research on the context aware computing for the Internet of Things. They pointed out that market research has shown a significant growth of sensor deployments over the past decade and has predicted a significant increment of the growth rate in the future. These sensors continuously generate enormous amounts of data. However, in order to add value to raw sensor data we need to understand it. Context-aware computing that understands sensor data has proven to be successful. In that article, from the angle of the IOT research context awareness, they provide the necessary background introduction of the Internet of things paradigm and context-aware basis. In [5], Sebastian et al. proposed the novel economic feasibility of multipath protocols in mobile Internet of Things applications. Eliminate imagine some service to be two terminal mobility and high availability and high bandwidth. However, the current environment with the cellular network and single way agreement may not be able to ensure adequate service level. As a result, of this study is to assess the economic feasibility of using the multipath protocol availability and increased bandwidth and several mobile operators. Through the use of cost-benefit analysis, single path selection model is to develop more path agreement. Demonstrate the use of the model, there are two potential mobile application scenarios, from increasing availability or bandwidth. In [6], Zhao's group conduct in-depth research on the multidimensional resource model for dynamic resource matching in internet of things. They conclude that many middleware solutions have been proposed for the integration of physical world with the Web. However, most leading middleware

solutions provide only limited resource matching and selection functionality. More related research could be found at [7].

II. THE SENSOR NETWORK SPECTRUM DETECTION

With the development of wireless communication, wireless spectrum has become increasingly scarce, but some of the frequency spectrum utilization is not filling urn. For more effective to improve spectrum utilization, need to further improve the traditional spectrum management method, therefore, which used in cognitive radio spectrum analysis strategy has become a hot research topic [8]. Cognitive radio spectrum can be detected and can be adjusted according to the use of the corresponding and new technique is an effective use of spectrum. Automatic spectrum detection the basis of a variety of cognitive wireless sensor network coexistence, but how to make the spectrum detection is more reliable is still a research hot spot. In fading channel, the multipath effect, shadow effect and local interference will cause the signal to noise ratio range is lower than the threshold, tests are not complete so a single wireless sensing technology is unreliable. But due to different position signal intensity in the network, if collaboration for distributed detection, through the network can avoid detection could not be completed. Support vector machine is a kind of based on statistical learning model and structure risk minimum principle of machine learning method, is widely used in statistical classification, applicable to linear separable and linear inseparable with under the small training samples can obtain the characteristics of the good classification effect. The SVM classifier can be used to training the time-domain signal spectrum. At the same time after using compression perception spectrum detection problem can be treated as linear inseparable case classification problem [9]. In the spectrum sensing algorithm based on compression perception and energy test, the computational complexity of system are mainly concentrated in the reconstruction of the signal, so we try to avoid the compressed signal reconstruction and direct use observation sequence test spectrum. In (1), we define the objective function.

$$\chi = \left\{ (x, z) : x \in R^N, x = \Psi s, \|s\|_0 \le k, \|s\|_2 \le R \right\} \quad (1)$$

Observation matrix is Gaussian random matrix, and the sparse matrix is orthogonal matrix, the two irrelevant, and compressed sensing matrix with isometric conditions for large probability constraints.

$$(1 - \varepsilon) \|s\|_2^2 \le \|\Theta s\|_2^2 \le (1 + \varepsilon) \|s\|_2^2 \quad (2)$$

Here we only care about the classification of the samples and not to reconstruct the original time domain signal, so does not need to know the sparse matrix. So in the time domain signal in a transform domain with known sparse features, direct observation matrix is used to change the time domain signal is mapped to a domain, and in the observational domain classifier training and sample classification, its performance and directly to classify performance close to the original time domain signal. The architecture of wireless sensor network, as shown in the Fig.1, a large number of sensor nodes are randomly distributed in the monitored area, to test the need of

physical quantities, these sensor nodes in accordance with the self-organization mode of network, with the method of multiple hops to transmit data to monitoring center or the Internet, users can monitor center for wireless sensor networks or the Internet [10]. As a result of the common sensor nodes communication ability is weak, often in wireless sensor networks based on region divided into many clusters, each cluster to set up a communication ability strong node as the cluster head, cluster head is responsible for collecting interest within this cluster node, and then through multiple hops way to transfer the information to the gathering node, the node is responsible for the exchange of information with the outside world [11].
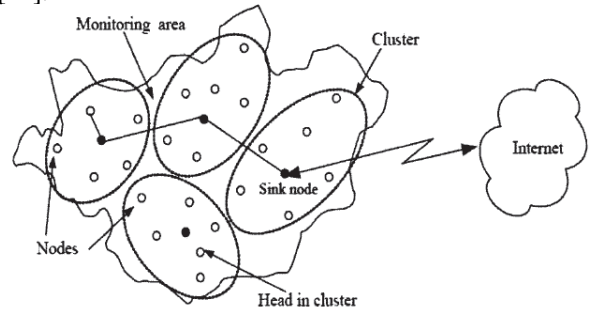

Figure 1. The Features and Architecture of Wireless Sensor Network

In the wireless sensor network, in addition to a small number of nodes need to move beyond, most nodes are stationary, and generally in a state of mobile cellular mobile telephone network users, how to ensure that the user call quality in mobile case, at the same time the use of the maximum save bandwidth, is a cellular mobile telephone network need to solve the problem. Suppose in a narrow band cognitive in sensor network have a primary user, it allows secondary users use the spectrum in spectrum free circumstances. In order to make full use of spectrum resources and does not affect the main users, secondary users must be able to quickly and accurately perceive the presence or absence of user signal. In order to improve cognitive performance, ordinary secondary user's perception of the local information transmitted to the fusion center, according to the fusion center receives the information of each node in the judgment [12]. Each sensor node spectrum perception can be regarded as a binary hypothesis test problem.

$$x_k(n) = \begin{cases} \xi_k(n), & H_0 \\ s_k(n) + \xi_k(n), & H_1 \end{cases} \quad (3)$$

Traditional energy detection method first received after the sampling signal modulus square, then the energy accumulation by using statistics, comparing with the decision threshold finally and makes a ruling which is shown in (4).

$$\begin{aligned} H_1 &: T_{CED} \ge \rho_{CED} \\ H_0 &: T_{CED} < \rho_{CED} \end{aligned} \quad (4)$$

Conclusion by statistical knowledge: if the n independent random variables are subject to Gaussian distribution, is that the sum of the squares of the N random variables to degrees of freedom for N card distribution [13]. When the average N random variables

not zero, they pose of the sum of the squares of the chi-square random variables are subject to the center. When the energy accumulation points when N is large enough, the use of central limit theorem, chi-square distribution can be approximate to Gaussian distribution denoted as the following.

$$H_1 : T_{CED} \sim \gamma \left(N \left(\sigma^2 + P \right), 2N \left(\sigma^2 + P \right)^2 \right)$$
$$H_0 : T_{CED} \sim \gamma \left(N \sigma^2, 2N \sigma^4 \right) \qquad (5)$$

Because of various cognitive node distributions in different geographical location, signal sampling, the perception of the starting time is not necessarily synchronous. At the same time, the perception to the fusion center data transmission between nodes when asked delay is not the same, these factors will seriously affect the synchronous collaboration sensory perception performance of the algorithm. In addition, the signal in a certain period of when to appear, when to exit in the spectrum is unpredictable, this may result in the phase spectrum perception signals had already disappeared. Data fusion center using Bayesian optimal decision rules of the likelihood ratio as the weight of each soft decision, and according to the statistical features of authorized spectrum occupied model, the sensory information from the asynchronous data fusion, realize the signal is about the existence of a certain spectrum soft decision, so as to complete the function of cooperative spectrum sensing. In (6), we define the compression sampling equation.

$$x = \sum_{i=1}^{N} s_i \psi_i \quad or \quad x = \Psi s \qquad (6)$$

The observation sequence, resulting from the compressed sensing is numerical data, and in the process of classifier training numerical larger data in the data set plays a leading role, influence of training to get the performance of the classifier. Signal observation sequence normalization preprocessing to interval, avoid big data in the data set plays a leading role and at the same time reduce the computational complexity. Collaboration with existing sequential detection often only does sequential detection in FC, and CSDS method in each node to do a first order penetration test. This is because for a certain period of logarithmic likelihood ratio, concrete data may be absolute value is very small, if need to directly upload the logarithmic likelihood ratio to FC, for the impact of judgment is very small, but it consumes more collaboration overhead [14].

At the beginning of each time slot, all nodes to check whether there is data transfer: if not, the network within the time slot to enter a dormant state; Spectrum detection. Otherwise, the network began a significant characteristics of wireless sensor network is to have a large number of intensive distribution of sensor nodes and this topology is very suitable for cooperative spectrum detection. Cooperative spectrum detection than the cooperative spectrum detection has higher reliability, especially in a multipath fading and shadow communication environment [15]. Assume that all sensor nodes in wireless sensor network cooperative spectrum detection on a channel at the same time. The scheduling node and the test results of each node in the fusion and decision, get the whole

network of the final test results. All data in the process of testing through public control channel transmission of wireless sensor network. If the detected a main user channel is idle, each sensor node in the letter on to scheduling node to transmit data. Through the reply to confirm when the frame in data transmission, the sensor node and data transmission scheduling nodes are known results. If the sensor network transmission to the main user channel is busy state, in the current time slot for the rest of time to enter a dormant state, wait until the next time slot ran test spectrum.

III. THE COGNITIVE RADIO NETWORK

Wireless sensor network is composed of a set composed of a large number of sensors deployed in monitoring area of the wireless network and it can be used for collaboration to perceive, collection and processing network coverage of the area of perception object information, and sent to the controller. Sensor nodes structure will be designed according to different application scenarios, the structure of the wireless sensor network node is used to describe the different periods and different types of sensor nodes. The role of power supply module is to provide energy to all sensor nodes, typically the initial energy of sensor nodes is equal, but in order to guarantee the transmission task, gateway and the initial value of the base station is larger. Information processing module is composed of two parts of the computing and storage, the sensor node itself, the collected data are stored in memory. Cluster head and base station is used to calculate function, used to allocate and manage the information transmission and will accept the information fusion processing. Sensor module main duty is to of all kinds of information collection and monitoring environment. After the commissioning of the wireless communication module, all sensor nodes can accomplish the communication between each other, work together and monitoring tasks.

The features of the cognitive radio network could be summarized as the following. (1) Sensor nodes are usually distributed in very extensive areas, in order to complete the perception of the real world, high density, sensor node deployment is also very intense. The whole wireless sensor network system reliability and quality of work rely on large-scale, redundancy of embedded devices to work together to implement and improve. In this way, through perceived information in the view of the different space signal-to-noise ratio is bigger. In a large amount of information, distributed processing method can effectively improve the accuracy of the monitoring, and lower precision requirements for a single sensor node. Due to the presence of large amounts of redundant nodes, the system fault tolerance. (2) Each sensor node in the wireless sensor network is random division in monitoring area, the location of the node can't accurate location in advance, the neighbor relationship between nodes are unpredictable, this requires that each sensor node itself has high ability of self-organization which can automatically configure and automatic management, through the network protocol and topology control mechanism automatically form forwarding monitoring data more wireless network. (3) Common cable communication distance of sensor nodes, in a few meters

to hundreds of meters. Nodes can communicate with in your communication within the scope of the adjacent nodes. But if you need to communicate with more than its communication range of the other nodes, you must pass by other nodes forwarding routing. The multi-hop routing of wireless sensor network is the common network node collaboration, that is to say, sometimes sensor nodes need to act as the sponsor of the information, forwarding and the recipient the three roles. (4) Sensor network is different from the address centered to the Internet, it is a task-based network and its aim is to obtain the data information. Sensor nodes in a network of all use serial number identification, the network node number is unified depends on the communication protocol of the system. Unable to determine the position of the sensor nodes in advance, the serial number of sensor nodes are depending on the system dynamic allocation, namely node number and the node position is no necessary link between the two. (5) Sensor energy supply in the wireless sensor network is usually carry from its own battery, once the battery runs out, that the sensor node will not be able to continue to work. Extend working hours of all nodes, therefore, that means the whole prolong the working life of the wireless sensor network. The node in the data transmission phase is the consumption of energy, this requests us in the case of complete the task does not affect the as far as possible to reduce data transmission, so as to achieve the purpose of save energy and prolong the life of the whole network.

Each user perception expressed with a node, if two users perception or conflicts between the interference and then these two users cannot use the same frequency at the same time, the need to add a cable between two nodes. Cloud computing is the core of the Internet of things intelligent information analysis. The use of cloud computing technology, make the real-time dynamic management of hundreds of millions of various types of objects. With the development of the Internet application, the increase of the number of the terminal, can process mass information, with the aid of cloud computing for auxiliary decision-making which will promote the information processing ability. Therefore, as a kind of virtualization, cloud computing solution of hardware and software operation, it can provide the Internet of things with efficient computation, storage capacity, provide extensive in the link of the Internet of things network engine. From the point of the Internet of things applications, their construction industries are of the system, is not convenient to a variety of business expansion, construction standard, if there is no unified standard Internet access, integration management platform, the Internet of things will be because of differences in various industries can't produce scale effect, increase the use of complexity and cost. At the same time there is even a collection and a collection is already assigned frequency band, said in accord with the constraint conditions and the distribution of target under the premise of a collection of frequencies assigned to the user perception. Another collection can be described using spectrum. The formula 7~8 defines the process.

$$N_{idle}^{s} = MN - N\sum_{q=1}^{M} i_{q} - \sum_{q=1}^{k} j_{q} \qquad (7)$$

$$P_{i}^{b} = \lambda_{i}^{s} / \sum_{j=1}^{k} \lambda_{j}^{s} P^{b} \qquad (8)$$

Due to the user at the same time, in the possessive spectrum space perception cannot produce interference to primary users, and perception of users and the main location is constantly changing, so the perception of different users, its can use frequencies are generally not the same. Network layer according to the perceived extension of business characteristics, to optimize the network features, better realize the content and the communication between, content and communication among the people as well as interpersonal communication, it requires must establish an end-to-end global network. There are a lot of equipment access in the Internet of things, is a ubiquitous access, heterogeneous access. Each user perception has the two corresponding collections, namely each node has two sets associated with it. Perception of users in a certain time and space can be used on the spectrum of a collection of resources, is the available spectrum matrix. Sensing spectrum section in the user access to the collection, will not affect the main users or other perception. Spectrum is usually divided into a series of orthogonal sub band, the main users take up one of the band, to a certain power to communicate and there is no interference between frequency and frequency band.

IV. EXPERIMENTAL ANALYSIS AND SIMULATION

In this section, we conduct numerical simulation on the proposed methodology to test the feasibility of our approach. Due to the interference phenomenon of wireless, within the cluster after cluster head, if the distance between them is less than the cluster radius, can produce interference between clusters. Secondary the closer the distance between the cluster head, then the interference between the clusters will be stronger. It may even cause message retransmission, lead to additional energy costs. So, setting up secondary clustering linear wireless sensor network protocols in each subnet irrigation area, to comprehensive consideration of cluster communication energy consumption and communication distance and cluster communication coverage overlap between the two communication interference problems. First of all, the former initial cluster number is 1, the average which is 0.5, effectively reduce the choice scope of cluster heads. Make a cluster head in a reasonable range. Because of the improvement after clustering algorithm in the initial clustering is introduced connectivity, so choose a reasonable initial cluster heads. Too much of the original algorithm to form cluster number and cluster structure is more fragmented, and the improved algorithm of cluster number is 6, the formation of cluster structure size is reasonable, good network connectivity; Second in the final cluster head election season 4 times per cluster head election probability increased. Although compared with the original algorithm improves the election error probability increase 2 times. But due to the introduction of connectivity in advance to ensure the final cluster head election is in a reasonable scope, so the accuracy will not reduce, and the algorithm can pass fewer iteration elects the final cluster heads. In the Fig. 2 and 3, we illustrate the first set of experiment which represents the average transmission power and sum rate, respectively. From the

experimental result, we could easily conclude that our method performs well.
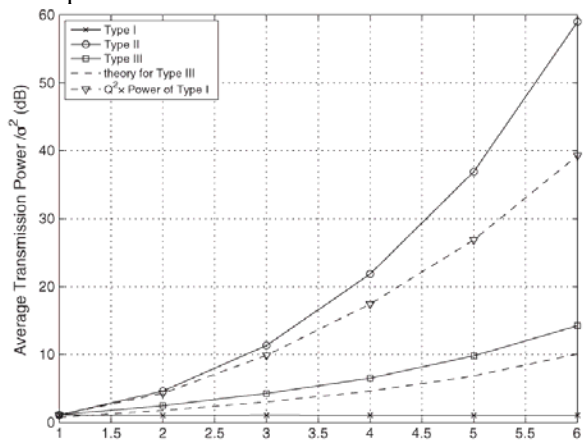

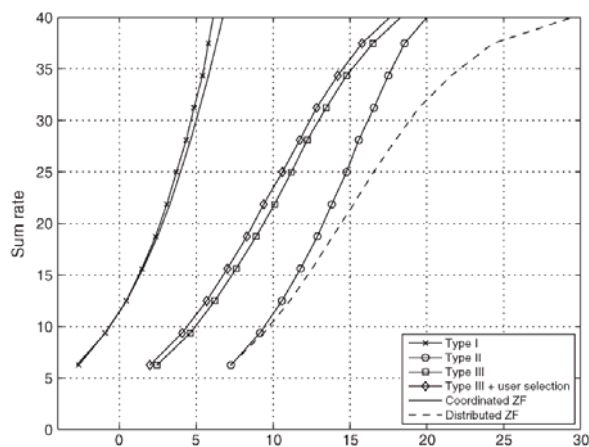Figure 2. The Experimental Result on Average Transmission Power

Figure 3. The Experimental Result on the Sum Rate

V. CONCLUSION AND SUMMARY

In this paper, we conduct theoretical analysis and numerical simulation on the sensor network spectrum detection technology based on cognitive radio network under the environment of Internet of Things. As another revolution of information industry, wireless sensor network the logical information world and the objective physical world together, changed the way of interaction between human and nature, the impact on human are comparable to those obtained with the emergence of the Internet. Along with the increasingly wide application of wireless sensor network, its security problems are brought to the attention of the people, the security problem is not only related to the network the confidentiality of information, and is of great significance for the stable operation of the network itself. Time synchronization protocol is wireless sensor network is an important part of the many applications of wireless sensor network, information query, for example, target tracking, node positioning, rely on accurate time synchronization, time synchronization protocol is also the foundation of many communication protocol run. Therefore, the safety of time synchronization protocol is the need of the wireless sensor network and stable operation which is also the foundation of multi-channel communication. Our propose

methodology solves the issues well which could be reflected from the experimental result.

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