Analysis of efficient Optimization Algorithm for Chaotic Information Nodes in Wireless Networks

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Abstract. Aiming improve the ability of fault detection and diagnosis of wireless network communication, the network chaotic information nodes are detected accurately and efficiently. An efficient detection method for chaotic information nodes in wireless networks is proposed based on quantization tracking and identification of sensor information. Firstly, the node connectivity graph model of wireless network communication is constructed, the link transmission channel of wireless network communication is analyzed, and the topology structure of distributed node is designed. Then the distributed sensor detection technique is used to detect the node output link equalization of wireless network communication. The higher-order spectral features of the output bit sequence stream of wireless network communication channel are extracted, and the anomaly of the characteristic quantity is extracted according to the characteristic quantity. The sensor information quantization tracking and identification technology is used to detect the chaotic information nodes in wireless network. Finally, the simulation test of high efficiency optimization detection of chaotic information nodes in wireless network communication is carried out. The results show that the accuracy of efficient optimization detection for chaotic information nodes is high by using this method. The quality of wireless network communication is improved because of the good real-time performance of network interrupt detection and fault diagnosis.

Keywords: Sensor Information, Quantization Tracking Identification, Wireless Network Communication, Chaotic Information Node, Efficient Optimization

1. Introduction

Wireless local area network (WLAN) secure communication nodes are randomly scattered throughout the monitored area and can be constructed through ad hoc networks. Wireless LAN secure communication node will detect the information, then process the detected data information, and then transmit the information processing results to the convergence node by multi-hop relay mode. All WLAN secure communication nodes can collect and process data, and can store, manage and merge data with other WLAN security communication nodes, and cooperate with other nodes to achieve related tasks. In addition, the wireless LAN secure communication detection node can be regarded as
an embedded system, but it is restricted by price, electricity, size and other factors, so the communication distance is limited and the processing capacity is weak\textsuperscript{[1]}. For nodes beyond the range of communication, multi-hop routing is used to transmit to convergent nodes. In the construction and communication of wireless network communication, because the physical layer adopts PON technology and Ethernet protocol to construct the network communication system, it is easy to appear the interruption and damage of the network access node, so it is necessary to improve the stability of the network communication\textsuperscript{[3]}. It is necessary to detect the network chaotic information nodes efficiently in time to realize the fast repair and fault diagnosis of the wireless network communication interruption fault. Therefore, it is of great value to study the efficient optimization detection technology of chaotic information nodes in wireless network communication, in order to optimize the network structure and improve the communication stability of wireless network communication\textsuperscript{[3]}.

Wireless network communication nodes are composed of a large number of routing nodes deployed in the communication area, which have wireless communication transmission performance. There are many reasons for the failure damage of wireless network communication nodes, such as energy depletion, node interruption. Because of the imbalance of communication channel, the efficient detection of wireless network communication damage is based on the detection of abnormal features and the extraction of damage information parameters of wireless network communication nodes. By analyzing the difference between the data forwarding and transmission between the chaotic information nodes and the normal nodes in wireless network communication, the chaotic information nodes of wireless network communication are detected efficiently. The convergent node has three main functions: processing function, communication function and storage function. The node has abundant memory resources, strong computing power and provides more energy. It can be regarded as a special gateway device with wireless communication interface\textsuperscript{[4]}. The node connects the WLAN secure communication network with the external network, realizes the communication between the WLAN secure communication network and the management node, and transmits the collected data information to the external network through the communication protocol conversion. Based on the Internet, Earth satellite or mobile communication network and other related carriers, the relevant information transmitted to the management node can be monitored by the user terminal. At the same time, the end user can complete the configuration of WLAN secure communication network, the management of WLAN secure communication nodes, the release of monitoring tasks, the collection of data return and other functions\textsuperscript{[5,6]}.

This paper presents an efficient detection method for chaotic information nodes in wireless networks based on quantization tracking and identification of sensor information. Firstly, the node connectivity graph model of wireless network communication is constructed, the link transmission channel analysis of wireless network communication is carried out, and the topology structure of distributed node is designed. Then the distributed sensor detection technique is used to detect the node output link equalization of wireless network communication. The higher-order spectral features of the output bit sequence stream of wireless network communication channel are extracted, and the anomaly of the characteristic quantity is extracted according to the characteristic quantity. The sensor information quantization tracking and identification technology is used to detect the chaotic information nodes in wireless network. Finally, the simulation test of the chaotic information node in wireless network is carried out, which shows the superior performance of this method.

2. Wireless Network Communication Node Connectivity Analysis and Topology Design

2.1. Estimation of Characteristic Parameters of Nodes

The node connectivity graph model of wireless network communication is constructed, the link transmission channel analysis of wireless network communication is carried out, the topology structure design and characteristic parameter estimation of distributed node in wireless network are carried out\textsuperscript{[7]}. The energy expansion loss and attenuation loss of wireless network communication chaotic information node are calculated, and the channel measurement model of wireless network
communication section is presented as follows:

\[ z_i^k = h_i^k(x_i, u_k) + v_i^k, \quad i = 1, 2, \ldots, M \]  

(1)

Considering the randomness of the spatial distribution of wireless network communication nodes, the crosstalk estimation method between nodes is used to detect the chaotic information nodes in the network communication channel. The model of the chaotic information node detection in the channel link is described as follows:

\[ x(k+1) = A(k)x(k) + \Gamma(k)w(k) \]  

(2)

\[ z_i(k) = H_i(k)x(k) + u_i(k), \quad i = 1, 2, \ldots, N \]  

(3)

Where, \( x(k) \in \mathbb{R}^n \) is the connected vector of each neighbor node in wireless network communication, \( A(k) \in \mathbb{R}^{n \times n} \) is the state measurement matrix of the routing chaotic information node of the network, and \( \Gamma(k) \) is the attenuation loss matrix. Considering the mutual coupling of \( N \) chaotic information nodes, the crosstalk between the nodes is generated and the interference is suppressed. The filter transfer function is set as:

\[ x(k+1) = A(k)x(k) + \Gamma(k)w(k) \]  

(4)

\[ z_i(k) = H_i(k)x(k) + u_i(k), \quad i = 1, 2, \ldots, N \]  

(5)

According to interference filtering, the problem of efficient optimization detection of chaotic information nodes in wireless network communication is transformed into the problem of detecting chaotic information nodes of signals transmitted between nodes\(^8\). Based on the quantization tracking fusion estimation method, the characteristic parameters of the nodes in wireless network communication are estimated, and the decision function of the node estimation of the chaotic information of the node output signal is obtained as follows:

\[ \begin{align*}
E[w(k)u_i^T(k)] &= B_i(k), \quad i = 1, 2, \ldots, N \\
E[u_i(k)u_j^T(k)] &= D_y(k), \quad i, j = 1, 2, \ldots N, i \neq j
\end{align*} \]  

(6)

The initial state of the communication channel between the effective nodes and the chaotic information nodes in wireless networks is \( x(0) \), high-order spectral characteristic, the mean value of which is \( x_o \), variance is \( P_o \), variance is estimated by adaptive quantization\(^9\).

2.2. Node Connectivity Graph Model of Wireless Network Communication

In this paper, the efficient detection method of chaotic information nodes for wireless network communication is studied. Firstly, the topology structure and node distribution model of wireless network communication are analyzed, and a binary directed graph \( G = (V, E) \) is used to represent the wireless network communication topology structure. Using EPON wavelength division multiplexing technology to control the network topology, the optimal distribution structure model of network communication node \( (x_s, y_s) \) is constructed, and the connectivity graph estimation results of Sink nodes in wireless network communication are obtained as follows:

\[ x_s = W_{sT} y \]  

(7)

Where, \( x_s = [x(\eta_1), \ldots, x(\eta_N)]^T \), According to the above analysis, the connected graph model of network node distribution for wireless network communication is obtained as shown in figure 1.
In the network node connectivity graph model of wireless network communication shown in Figure 1, the channel attenuation characteristic function of wireless network communication is calculated, the abnormal output signal of chaotic information node is analyzed, the channel attenuation characteristic is analyzed, and the root of wireless network communication is analyzed. According to the difference of transmission channel attenuation and energy output between Source and Sink nodes, chaotic information node detection is carried out. Based on the topology structure and node distribution model of wireless network, the efficient optimization detection of chaotic information nodes in wireless network communication is studied\[10-12\].

3. Network Chaotic Information Node Efficient Optimization Detection Optimization

3.1. Node Output Link Equalization Detection in Wireless Network Communication

On the basis of constructing the node connectivity graph model of wireless network communication, analyzing the link transmission channel of wireless network communication and optimizing the network topology structure, the chaotic information node of wireless network communication is efficiently optimized\[13\]. In this paper, an efficient detection method based on quantization tracking and identification of sensor information for chaotic information nodes in wireless network communication is proposed. Distributed sensor detection technology is used to carry out node transmission in wireless network communication. In the neighborhood neighborhood \(L = \{L_1, L_2\}\) range of chaotic information nodes, the output link equalization detection function of wireless network communication is as follows:

\[
i_1 = \begin{cases} 
  i - 1 & \text{if } i \neq 1 \\
  C_L & \text{if } i = 1
\end{cases}
\]

\[
i_2 = \begin{cases} 
  i + 1 & \text{if } i \neq C_L \\
  1 & \text{if } i = C_L
\end{cases}
\]

In the communication coverage area of nodes, the differences of wireless network communication source nodes are extracted, the chaotic information nodes are efficiently detected, and the grid area of node distribution is divided by subgraph segmentation method of source nodes\[14\]. Under the shortest path detection, the triangular network structure of efficient optimization detection of chaotic information nodes is \(\Delta A = GFA, \Delta B = GFB\). In the connected state, the node output link equalization detection function of wireless network communication is described as:

\[
x_i^{(k+1)} = (1 - \omega)x_i^{(k)} + \frac{\omega}{a_{n_i}} \left( b_i - \sum_{j=1}^{i-1} a_{ij}x_j^{(k+1)} - \sum_{j=i+1}^{n} a_{ij}x_j^{(k)} \right)
\]

\[i = 1, 2, \ldots, n\]

\[k = 1, 2, \ldots, n\]
Considering the connectivity of wireless network, the chaotic information node is detected under the minimum hops and the shortest delay. The high order spectrum of the chaotic information node in wireless network is obtained, and the feature extraction is carried out, and the reverse efficient optimization detection of the chaotic information node is carried out according to the result of the node output link equalization detection of the wireless network communication.

3.2. Efficient Optimization Detection Of Chaotic Information Nodes

In the link layer transmission channel, the chaotic information nodes are efficiently optimized on \( m \) terminal links\(^{[15]} \). The transmission data stream of the network output after the node output link equalization detection is expressed as follows:

\[
x(k) = [x_1(k), x_2(k), \ldots, x_m(k)] \quad i = 1, 2, \ldots, m
\]

FDMA protocol is used to construct the wireless network communication routing protocol, and the irregular triangular network model is used to detect and deploy the nodes efficiently. Under the shortest geometric distance, the wireless network communication information is extracted by the geometric distance method. The higher-order spectral characteristics of the bit-sequence flow of channel output are described. The correlation coefficients between chaotic information nodes and normal nodes are \( p \) and \( q \). The chaotic information nodes with connectivity of \( T_{Lx} (l< L) \) are obtained by adaptive link recombination of any Sink node \( p_i (i \in [i, i]) \). The results of radial distance calculation for efficient optimization detection are expressed as follows:

\[
T_{l1} = \sqrt{F_{p1}^2 + F_{q1}^2}
\]

Along the Source and Sink nodes, the network information nodes are searched and inserted into \( m \) virtual nodes according to different interrupt attributes on the line between the first two points of the cluster in wireless network communication, and \( m \) is obtained according to the following algorithm:

\[
m = \begin{cases} 
1, & DS \leq R \\
\frac{DS}{R}, & DS > R 
\end{cases}
\]

Where, the distributed Euclidean distance of each chaotic information node represented by \( DS \) in high-dimensional space is obtained, and the information of normal nodes and chaotic information nodes in wireless network communication can be obtained by means of associative weight \( L \) and \( \varphi \), which satisfy the network connectivity. The connectivity characteristic difference function is expressed as:

\[
L = \sqrt{\left(p_{i, s}\right)^2 + \left(p_{i, s}\right)^2 - 2 \left(p_{i, s}\right) \times \cos \angle{s, p_{i, s}}}
\]

\[
\varphi = \arccos \left( \frac{\left(p_{i, s}\right)^2 + \left(s, s\right)^2 - \left(p_{i, s}\right)^2}{2 \left(s, s\right) \times \left(p_{i, s}\right)} \right)
\]

The vector quantization decomposition method is used to detect the coordinates of the chaotic information nodes in the whole coverage area. The results of the spatial distribution vector calculation of the chaotic information nodes in polar coordinate system are expressed as follows:

\[
\left(\overrightarrow{pp}\right)^2 + \left(\overrightarrow{pp}\right)^2 - 2 \left(\overrightarrow{pp}\right) \times \cos \angle{pp'} = \left(\overrightarrow{pp'}\right)^2
\]

According to the topology change of network connected domain, the measurement distance of wireless network communication node is obtained as follows:

\[
\overrightarrow{pp'} = \overrightarrow{pp} \times \cos \angle{pp'} + \left(\overrightarrow{pp'}\right)^2 \times \sin \angle{pp'}
\]
According to the feature extraction results of high-order spectrum, the sensor information quantization tracking and identification technology is used to detect the chaotic information nodes in wireless network, and the geometric measure distance between the chaotic information nodes is solved. The calculation formulas are expressed as follows:

\[ d(i, j) = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \]  

Where, \( x_i, y_i, x_j, y_j \) represent the horizontal and vertical coordinates of the chaotic information node and the normal node \( j \), and the \( d(i, j) \) represents the Euclidean distance between the chaotic information nodes of the two wireless networks.

4. Analysis of Simulation Experiment

Aiming to test the application performance of this algorithm in efficient optimization detection and network connectivity testing of chaotic information nodes in wireless network, simulation experiments are carried out. The simulation software is Matlab 7. The simulation platform of wireless network communication is constructed by Ethernet switch of 1000Mb/s. The number of Sink nodes and source nodes in wireless network communication is 28, the number of source nodes is 1200, the number of transfer nodes is 54, and the control number of LLC layer is responsible for the control number. According to the error problem, For the case where the data is being transmitted, if the error data is detected in the receiving node, the sending node is notified to retransmit the frame; When the receiving node receives the frame data accurately, the detection of LLC layer is completed. The MAC layer is responsible for allocating fair and effective communication resources to the secure communication nodes of WLAN, which is implemented by deterministic allocation, competition occupation and random access. There are dense wireless local area network secure communication nodes in the sensor area. For data transmission, the MAC layer will establish communication connection. The initial distribution interval between wireless multi-hop nodes and nodes is 0.01. According to the above simulation environment and parameter design, the simulation experiment of efficient optimization detection of chaotic information nodes is carried out. The network section is carried out, the time domain waveform of the collected signal is shown in Fig. 2.

![Figure 2. Transmission data acquisition of wireless network communication](image-url)
network chaotic information node is implemented. The optimal detection results of three groups of chaotic information nodes are shown in figure 3.

![Figure 3](image-url)

**Figure 3.** Efficient optimization detection results of network chaotic information nodes

The result of analysis figure 3 shows that the method of this paper is used for efficient optimization detection of chaotic information nodes. According to the peak value of feature variables, the location of chaotic information nodes can be accurately identified. In order to quantitatively compare the performance of the algorithm, the algorithm is not used. In the same method, the root mean square error and the delay of the output link equalization detection are tested. The comparison of the test results is shown in figure 4, and the analytical figure 4 shows that the proposed method has better optimization ability and lower delay in the detection of chaotic information nodes.

![Figure 4](image-url)

**Figure 4.** Performance comparison of node optimization

5. Conclusions
In this paper, the problem of efficient optimization detection and output link equalization detection for chaotic information nodes in wireless network communication is studied, and an efficient optimization detection method for chaotic information nodes in wireless network communication is proposed based on quantization tracking and identification technology of sensor information. The node connectivity graph model of wireless network communication is constructed, the link transmission channel of
wireless network communication is analyzed, and the topology design of distributed node is constructed. The distributed sensor detection technique is used to detect the node output link equalization in wireless network communication. The higher-order spectrum features of the output bit sequence stream of wireless network communication channel are extracted. According to the anomaly of the extracted feature quantity, the transmission is adopted. Sense information quantization tracking and identification technology is used to detect the chaotic information nodes in wireless network. The research shows that the proposed method is more accurate and has a shorter delay in the detection of chaotic information nodes in wireless networks, which improves the connectivity of the network. This method has good application value in wireless network communication fault node location detection.

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