Research on Load Balancing Control of Internet of Things (IoT) Link Based on Sparse Random Clustering

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Abstract: Aiming at the problems of poor channel balancing control ability and high output bit error rate in traditional IoT link load balancing control methods, an improved ant colony algorithm based load balancing control method for IoT link is proposed. This paper constructs the channel transmission model of IoT, uses sparse random clustering analysis method to detect the load characteristics of Internet of things links, and extracts the statistical characteristics of IoT link. The output balance control and interference suppression of IoT link are carried out by matching filter detection method, and the load balance of IoT link is fuzzy control combined with fuzzy PID control method. The simulation results show that the proposed method has good self-adaptability, strong channel equalization control ability and lower output bit error rate.

1. Introduction
With the rapid development of IoT communication technology, the load of IoT link is increasing, which requires load balancing scheduling of IoT link. Combined with the channel balance control method of the Internet of things link, the adaptive allocation design of the load link of IoT link is carried out to improve the load balancing scheduling ability of IoT link [1]. The research on the load balance control of IoT is based on the information transmission control of IoT. The adaptive random link forwarding protocol is used to control the load balance of IoT link. The interference suppression method is used to detect the interference filter in the process of the load balance control of the Internet of things link, so as to realize the channel balanced scheduling and optimal configuration [2].

This study proposes a link load balancing control method based on sparse random clustering. This paper constructs the channel transmission model of IoT, uses the decision feedback equalizer to detect the correlation in the process of the IoT link allocation, extracts the statistical characteristics of the network link load, and realizes the load balance control of the IoT link combined with the channel balancing method. Finally, the simulation experiment is carried out, and the results show that the research method can improve the link load balance control ability of IoT superior performance.

2. IoT link channel transmission model
In order to realize the load balancing control of IoT link based on sparse random clustering, the channel transmission model of IoT link is constructed, and the sparse random clustering analysis method is used to detect the load characteristics of IoT link [3]. The distribution distance of transmission symbol interval of IoT link is $d$, and the $T/2$ tap interval sampling method is used to control the transmission of IoT link. The adaptive characteristic distributed control model of IoT link transmission is constructed by using wireless equalization configuration method:
\[ x_m(t) = \sum_{i=1}^{l} s_i(t)e^{j\phi_i} + n_m(t), \quad -p + 1 \leq m \leq p \quad (1) \]

In Eq. (1), \( s_i(t) \) is the state characteristic quantity of the link transmission node of IoT, and \( x_m(t) \) is the output matrix of the link of IoT. Fuzzy information scheduling method is adopted to carry out load balancing scheduling of the link transmission of IoT [4]. The fuzziness of the link load information received by \( m \) array is detected, and the impulse response model of the link load of IoT is given as follows:

\[ h(t) = \sum a_i(t)e^{j\theta_i(t)}\delta(t-iT_s) \quad (2) \]

In Eq. (2), \( \theta_i(t) \) represents the transmission spectral density characteristic quantity of the link load of IoT. The spatial sampling method is adopted to carry out fuzzy clustering, and the length of clustering distribution is \( T \). Then the baud rate is used to carry out the balanced control of IoT link load, and IoT link load can be expressed as:

\[ x(t) = [x_{p+1}(t), x_{p+2}(t), \ldots, x_p(t)]^T \quad (3) \]

\[ s(t) = [s_1(t), s_2(t), \ldots, s_{m-1}(t)]^T \quad (4) \]

The multi-path spread channel model of IoT link is constructed. The channel equalization method is adopted to carry out the channel equalization configuration of IoT link load, and the equalization scheduling function is obtained as follows:

\[ e(x,t) = \sum a_n(t)e^{-j2\pi\tau_n(t)}\delta(t-\tau_n(t)) \quad (5) \]

In Eq. (5), \( a_n(t) \) is the extension loss of IoT link in path \( n \), and \( \tau_n(t) \) is the delay of load transmission of IoT link in path \( n \). Adaptive learning method is adopted to carry out load balancing scheduling of IoT link [5], and the link transmission learning function of IoT is obtained as follows:

\[
\begin{aligned}
&\min \sum_{1 \leq i \leq K} \sum_{e \leq k(e)} \frac{f(e,i)}{C(e,i)} \\
&0 \leq f(e,i) \leq C(e,i) \\
&F = \text{const} \\
&\sum_{1 \leq i \leq K} \sum_{e \leq k(e)} \frac{f(e,i)}{C(e,i)} \leq k(v)
\end{aligned}
\]

In multi-path channel, multi-path suppression method is adopted for channel synthesis to realize load balancing configuration of IoT link [6]. The schematic diagram is shown in Fig. 1.

![Fig.1 Schematic diagram of load balancing configuration of IoT link](image-url)
3. IoT link load balancing control optimization

According to the channel transmission model of IoT link and the detection results of load characteristics, the output balance control and interference suppression of IoT link are carried out by using matched filter detection method, and the fuzzy PID control method is used for the fuzzy control of load balance of IoT link. In the process of channel spread spectrum, the conjugate characteristic solution of the load distribution of IoT link is obtained as follows:

\[ d(t) = a(t)c(t) = \sum_{n=0}^{\infty} d_n g_n(t - nT_c) \]  

(7)

In Eq. (7):

\[ d_n = \begin{cases} +1 & a_n = c_n \\ -1 & a_n \neq c_n \end{cases} \quad (n - 1)T_c \leq t \leq nT_c \]  

(8)

The impulse response modulation method is used to control the load of the network, and the channel equalization scheduling model of IoT link is constructed. Sparse Bayesian learning method is adopted to obtain the load balancing control error function of IoT link:

\[ \hat{e}(k) = z_s(k)[|z(k)|^2 - \hat{z}_s^2(k)] + jz_t(k)[|z(k)|^2 - \hat{z}_t^2(k)] \]  

(9)

In Eq. (9), \( \text{sgn}(\cdot) \) represents the symbolic function, and \( \hat{z}_s(k) \) and \( \hat{z}_t(k) \) are the adaptive weighting coefficients of the link load of IoT. Under the condition of fixed carrier frequency, the statistical time series of the receiver of IoT link is \( c'(t) \), and the output code elements of IoT link are interpolated zero \(^{[7,8]}\), and the subspace class functions of the coherent source are obtained as follows:

\[ J_{\text{MMDMMA} - R} = c'(t)E[(z_s^2(k) - R_{\text{MMDMMA} - R}(k))^2] \cdot \rho(k) + [1 - \rho(k)] \cdot E[(z_s^2(k) - R_s)^2] \]  

(10)

Eq. (10) can be simplified to Eq. (16):

\[ J_{\text{MMDMMA}} = J_{\text{MMDMMA} - R} + J_{\text{MMDMMA} - I} \]  

(11)

Extract the associated characteristic quantity of the network link flow, and conduct synchronous mixing processing for the random sequence generated at the output end of IoT link and the interference signal \( c(t) \) at the input. When \( c(t) = c'(t) \) \( B^{[9,10]} \). The transmission delay between elements of the uniform line array of IoT is as follows:

\[ e(k) = z(k)[|z(k)|^2 - R] \]  

(12)

The frequency domain value of the link output of IoT is iteratively solved, and the matched filter detection is adopted to suppress the interference, as shown in Fig. 2.

![Fig. 2 Matched filter detector](image-url)
4. Simulation experiment and analysis

In order to verify the application performance of the research method in the realization of the load balancing control of IoT, the simulation experiment is carried out. The bandwidth of IoT link load transmission is 12 MHz, the sampling frequency is 5 MHz, the azimuth angle of IoT nodes is – 10° and the layout distance of IOT nodes is 100-300m. The signal duration is 1s, the signal frequency is 300Hz in the first 0.5s, and 350Hz in the last 0.5s. According to the above simulation parameter settings, the load balancing control of IoT link is carried out, and the transmitted IoT link load is obtained, as shown in Fig. 3.

![Fig. 3 Link load of IoT](image)

In order to verify the channel equalization control capability of the research method, based on the above simulation experiment environment, the load balancing configuration is carried out according to IoT load in Fig. 4, and the load balancing output is shown in Fig. 4.

![Fig.4 Load balancing output](image)

In Fig. 4, the method presented in this paper can effectively control the load of IoT link, and the output amplitude of load balancing is controlled within the range of -2~2Kbps, and the output balance of the control is good.

In order to further verify that the research method can effectively reduce the output bit error rate, based on the above experimental environment, compared with the traditional IoT link load balancing method based on classification optimization, the root mean square error under different signal-to-noise ratio environment is tested. The smaller the error is, the better the control effect is. The experimental results are shown in Fig. 5.
In Fig. 6, the root mean square error of the traditional method is far greater than that of the research method, which shows that the research method can effectively reduce the output bit error rate of the load balancing control of IoT link, and provides a favorable scientific basis for the load balancing control of IoT link.

5. Conclusion
Because the traditional load balancing control methods of IoT have poor channel balance control ability and cannot effectively reduce the output bit error rate, this paper proposes a load balancing control method of IoT based on sparse random clustering. The multi-path extended channel model of IoT is constructed. The channel balancing method is used to configure the channel balance of the Internet of things link load, and the BSB algorithm is used to estimate the DOA. Based on the specific array structure, the load balancing ability of IoT link is improved. The relevance detection in the process of IoT link allocation is carried out by using decision feedback equalizer, and the statistical characteristics of network link load are extracted. Based on the correlation spectrum analysis method, the adaptive scheduling of IoT link load transmission is carried out, and the load balancing control of IoT link is completed by sparse random clustering. The experimental analysis shows that the research method has strong channel balancing control ability and low output bit error rate, which improves the stability of the network.

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