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Energy Internet Oriented Services Awareness in Elastic Optical Networks

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Abstract. Aimed to improve the ability of EON (Elastic Optical Networks) to support multiple services brought by Energy Internet, this paper proposes a Echo-State-Network Based Services Awareness schem of EON system for Energy Internet. The proposed scheme is able to be aware of characteristics of multiple services and to match their requirements with better quality. Thus, resources allocation optimization is enabled by the proposed scheme in each edge node. Simulation results show that this proposed approach can greatly improve the supporting ability for multiple services of Energy Internet with better performance from aspects of both packet loss rate and time delay performances.

1. Introduction

With the rapid development of the energy Internet, energy interconnection and communication access business types are increasingly diversified, Elastic Optical Networks (EON), with its high bandwidth and high flexibility, is expected to become an important technology for energy interconnection service communication network.[1]

The optical communication technology of energy Internet is not only to meet the requirements of bandwidth, flexibility and reliability of energy interconnection, but also to support the diversification of energy and new business. Therefore, the operational awareness of power elastic optical networks is particularly important. Business awareness is usually defined as identifying the service type of service flow in a perceptual communication network, the QoS requirements of the service, the traffic priority, and its bandwidth and real-time[2].[1]

At present, most of the service sensing technology of optical communication network adopts the method of detecting protocol word, port number and IP address included in the data frame. However, with the diversification and complexity of the new smart grid business, the traditional method is becoming more and more difficult to adapt to the development trend of the business. Therefore, the use of business flow transmission characteristics of business awareness has become a new research direction[3-8]. The literature [3-4] shows that there is a certain correspondence between the statistical properties of the network traffic and the application protocol, but these mechanisms have insufficient

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accuracy for the perception of the business type. In [5], the feature set extraction method of service flow is proposed to realize the awareness of service flow. In the literature [6], the IP packet length, packet arrival interval and order are extracted from the service flow, and the traffic flow recognition is realized by the neural network algorithm. However, the complexity of the method is higher and the computation is larger.

Therefore, a highly accurate and complex business awareness approach is particularly important. In this paper, we propose a flexible optical network service flow sensing technology based on Echo State Network (ESN), which can ensure the awareness and support of diversified services while playing the flexible bandwidth of flexible optical network ability.

2. Echo state network classification algorithm

2.1 Echo state network principle

The structure of the echo state network is shown in Fig. 1, which consists of input layer, core layer and output layer[9-13]. Assuming that the echo state network consists of K input units, N reserve pool processing units, and L output units. The basic equations of the echo state network are equations (1) and (2):

$$x(n+1) = f\left(W^{in}u(n+1) + Wx(n) + W^{back}y(n)\right) \tag{1}$$

$$y(n+1) = f^{out}\left(W^{out}u(n+1) + Wx(n+1) + W^{back}y(n)\right) \tag{2}$$

Where u (n) is the input variable of ESN, x (n) is the state variable, y (n) is the output variable; In addition, f and foutt can be regarded as the excitation function of the processing unit and the output unit in the ESN model. The input variable is connected by Win and ESN processing unit, W is the weight between ESN internal processing unit, Wback represents the connection weight of output layer and core layer, Wout is the connection weight of core layer and output layer. In addition, Win, W and Wback are usually set to constant, and Wout can be obtained through a certain training.

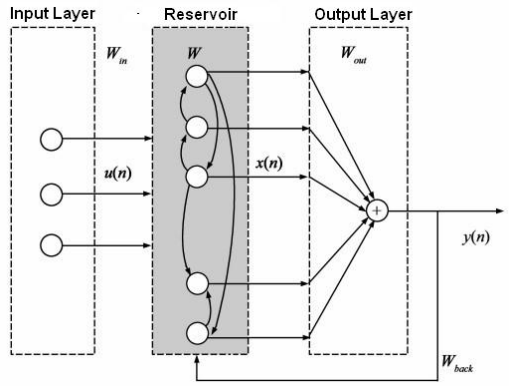

Figure 1. Echo state network diagram

In the training of ESN, the sample data can be excited by the linear regression to correct the internal parameters of ESN after each round of training, and the mean square error can be minimized by using the randomly generated weight matrix Win and Wback to excite the processing unit of the core layer.

2.2 Echo state network classification algorithm

The basic principle of the echo state network classification method is shown in equation (3), where n represents only different samples, not time. In the process of classification training, the input samples

must always be kept constant until the pool state variables become stable, making the difference between the two iterations before and after the minimum[14].

$$\begin{cases} x(n+1)^{(i)} = W^{in}u(n+1) + Wx(n+1)^{(i-1)} \\ x(n+1)^{(0)} = 0 \end{cases} \tag{3}$$

The advantage of this algorithm is that it uses the reserve pool processing unit to activate the function to stabilize the state variables before processing it, and still maintain the network training process of echo state simple, with excellent performance.

3. Business - aware Mechanism Based on Echo State Network Algorithm

3.1 ESN - based business classification awareness principle

In order to further improve the operational awareness of the elastic optical network, this paper proposes a service perception based on the echo state network algorithm. Business-based ESN algorithm is essentially a mapping of business characteristics to business type. Its essence is to determine the classification process of decision attributes (business types) based on condition attributes (business characteristics). In this paper, the business is divided into packet loss-sensitive business and the delay-sensitive business business sense, each business according to the priority is divided into high, medium and low three grades.

Service perception based on echo state network algorithm is divided into three parts: feature extraction, ESN training and ESN decision. The edge node of the elastic optical network extracts the main characteristic parameters of the bidirectional service stream Pi, mainly including frame length, service flow duration and service packet flow time interval, which forms a feature set of service flow u={u1,u2,…,uk,…}. The feature set u of the service flow is input to the trained echo state network model, and the classification type of the service belongs is obtained by calculating $\boldsymbol{W^{out}}$.

3.2 Implementation of business-aware mechanisms

According to the characteristics of the network system composed of the edge node and the intermediate node, the service awareness scheme is proposed according to the realization mode of the service perception mechanism. The process of realizing the business-aware mechanism of the power elastic optical network is shown in Fig2.

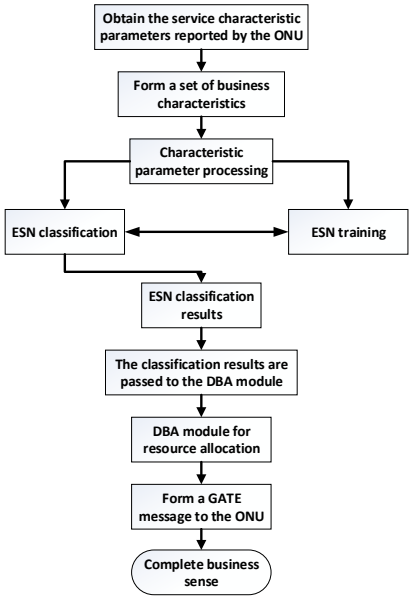

Figure 2. Power Elastic Optical Network Business Perception Process

In the flexible optical network, the service-aware mechanism proposed in this paper is mainly composed of the service-aware module embedded in the edge node. The service awareness module is responsible for initializing the ESN configuration and complex ESN training. The edge node can independently assume the local service awareness function after the ESN classifier is trained. The edge node extracts the characteristic parameters of the service flow, and allocates the corresponding bandwidth and queue priority according to the QoS requirements of the service flow to optimize the multi-service awareness and efficient matching capability of the flexible optical network.

3.3 Analysis of complexity

Complexity is one of the key performance indicators of ESN-based multi-service aware algorithms. Only a high-accuracy and moderate complex core algorithm model can make business-aware technology achievable. Using the ESN algorithm model as the core, to obtain the result of business flow recognition calculation, only one addition and one subtraction and two multiplication are needed. Therefore, the computational complexity can be regarded as O (1).

Complexity is usually proportional to the number of members of the input parameter set. Assuming that the members of the input parameter set have m classes, the computational complexity of ESN is O (m) × O (1). Therefore, the algorithm model proposed in this paper has low complexity, while ensuring the perceived accuracy of the traffic flow.

4. Simulation results and analysis

In order to verify the proposed mechanism, this paper builds a simulation system of elastic optical network based on NS2 simulation software platform. The simulation system is simulated by an elastic optical network with 32 nodes. The local communication access with energy interconnection is taken as a typical business scenario, and the flexible optical network with business perception mechanism and the flexible optical network without service perception are compared by simulation. In the simulation, the service type is divided into two categories: packet loss rate sensitive service and delay sensitive service. Each type of service internal priority is divided into two levels: high priority service and low priority service.

Figure 3 shows the relationship between the accuracy of business perception and the number of training. It can be seen that with the increase of the number of training, the accuracy of business

perception is improved. The well-trained echo state network algorithm can guarantee the accuracy of classification of business classification.

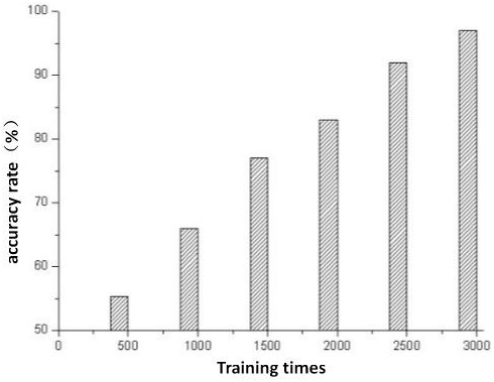

Figure 3. Relationship between the accuracy of business perception and the number of training

In the flexible optical network system, this paper uses the mechanism (business perception) and the traditional non-business perception mechanism to simulate. Figure 4 and Figure 5 is the comparison of the results.

Compared with the simulation results of Fig.4 and Fig.5, the packet loss rate and real-time performance of the elastic optical network tend to be degraded as the network traffic load increases. Under the condition of heavy load of elastic negative network, this paper is superior to the traditional elastic optical network mechanism in the two important indexes of packet loss rate and transmission delay of high priority service. On the other hand, since the low priority class service requires lower transmission delay and packet loss rate, the mechanism of this paper is in a way to reduce the cost of such business performance in exchange for the overall business service quality, especially high priority business.

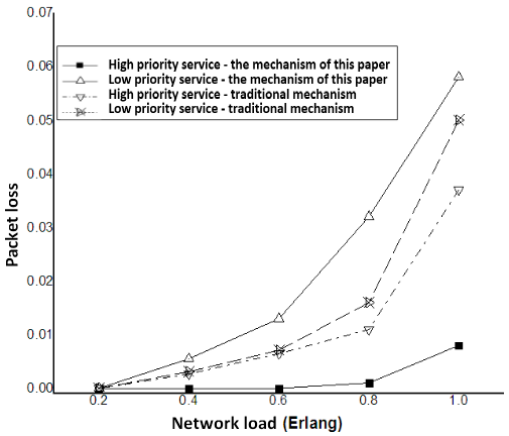

Figure 4 Comparison of packet loss rate

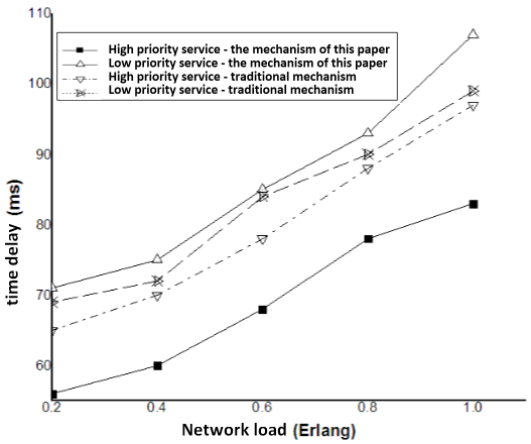

Figure 5 Delay comparison

To sum up, the service-aware approach mentioned in this paper enables different types and priorities of services to be matched with support, and to ensure the overall quality of service to the business. Therefore, compared with non-service-aware flexible optical network, the mechanism mentioned in this paper can effectively enhance the ability of power elastic optical network to support multi-service differentiation and optimize its service-oriented resource allocation effect.

5. Conclusion

In order to improve the active support capability of energy interconnection multi-service and the typical algorithm of echo state network of artificial intelligence, this paper proposes a service-aware method of

power elastic optical network based on echo state network algorithm. The simulation results show that the service-aware technology proposed in this paper can improve the bandwidth and real-time performance of the flexible optical network, and can effectively enhance the resilience of the elastic optical network to the active capability of the energy interconnection multi-service, and finally realize the new business needs of the optical network and energy Internet The efficient match.

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