Research on the business QoS and trustworthy and controllable strategies mechanism for energy internet

Geng Zhang¹, Meiling Lu²,³, Dahua Zhang¹, Liang Zhou¹ and Likang Li¹

¹Information & communication Dept of China Electric Power Research Institute, Beijing, 100192, China
²Institute of Electrical and Electronic Engineering, North China Electric Power University, Beijing, 102206, China

E-mail: lumeiling@ncepu.edu.cn

Abstract. Energy internet is a kind of power sharing network, which can realize the bidirectional flow of energy information on the basis of the existing power grid. It puts forward higher requirements for reliability and controllability of information communication, and all kinds of business QoS of the backbone network. So the research of business QoS and trustworthy and controllable strategies mechanism have an important significance for the development of energy internet. This paper mainly studies how to use the software defined network (SDN) to achieve business QoS, and provide QoS support for all kinds of business of the energy internet. Combined with the current development situation of the energy internet in our country, this paper researches the trustworthy and controllable strategies mechanism for energy internet, and proposes the transition scheme of the IPv6 credible network architecture based on SDN. This coordinates the contradiction between the growing demand for energy internet applications and the limitations of the energy internet technology itself.

1. Introduction

In recent years, with the sustained growth of the world's total energy consumption, energy structure has been adjusted. The global fossil energy resources are facing resource exhaustion and other practical problems. To solve the problem effectively, clean energy is being developed and used in large scale [1]. Global energy internet has a global and strategic significance for the coordinated development of the world economy and environment [2].

The normal work of the energy internet needs safe and reliable information and communication network. With the continuous deepening of the construction of energy internet, information and communication infrastructure is becoming more and more important [3]. Compared with the traditional Internet, energy exchange in the energy internet requires more reliability, so energy internet requires more controllability of the information and communication network under the premise of open network. To achieve better controllability and reliability, we can refer to the latest software defined network technology. The data forwarding and controlling is separated through the software defined network (SDN). It not only enhances the controllability, also makes the management more convenient. In addition, SDN technology can also provide more security, flexible security policy, convenience for the dynamic deployment and configuration [4].

With the improvement of the intelligent degree of energy internet, many aspects of energy internet will mostly use IP technology in information and communication area. Intelligent sensor and
intelligent terminal has been widely used. With the exhaustion of global IPv4 address resources, IPv4 address resources in China is scarce, is not enough for the needs of the development of energy internet [5]. Large power grid which is as the backbone network of the energy internet is bound to put forward higher requirements for the power quality service level in the future. Also various types of service business of power grid will increase requirements of data integrity, accuracy, timeliness, security and QoS. Limited to QoS capabilities of IPv4 technology, QoS is basically no application in the power grid data communication network of our country. Due to the lack of a reasonable QoS planning, a variety of businesses of different types and different communication performance requirements influence each other with the parallel transmission in the backbone data network.

In [6], an application programmable interface for QoS based on SDN is designed for video conference and streaming media. The application interface has good flexibility and scalability, which provides support for QoS applications. A network performance management system based on SDN is proposed in [7]. And the system has many advantages, such as intelligence, high reliability and security. In [8], the author proposed the trustworthy and controllable network architecture by attaching to the present network architecture with a four lays of trustworthy and controllable logical architecture. In [9], a method to realize IPv4/IPv6 protocol conversion based on SDN is proposed, which separates the protocol conversion function and the message forwarding function.

This paper takes advantage of SDN to achieve business QoS. Business priority module, network monitoring module and strategy formulation module are deployed in application layer of SDN network. It divides and sets the priority of various businesses according to the actual situation of the energy Internet and certain rules. Different priorities of the businesses own different bandwidth resources and transmission flow. The paper chooses queuing mechanisms provided by the OpenFlow protocol to achieve bandwidth guarantee for different types of services. The implementation architecture of business QoS based on SDN are introduced in detail. Finally, the paper puts forward IPv6 credible network structure transition scheme to help to put the proposed network architecture into practical application as soon as possible.

2. IPv4/IPv6 transition technology

At present, China has only about 0.33 billion IPv4 addresses. It can’t meet the rapid growth of application requirements even if a large number of applications of address translation technology to delay the IPv4 address consumption. And it also significantly increased network complexity and difficulty of management, reduced the network and information security level and QoS. Compared with IPv4, IPv6 technology has large amount of address space, and it supports for mobile IP seamless connection. Through new IPv6 flow label field, it is able to identify the same type of data flow and provide efficient QoS support for different businesses. The implementation architecture of business QoS based on SDN are introduced in detail. Finally, the paper puts forward IPv6 credible network structure transition scheme to help to put the proposed network architecture into practical application as soon as possible.

| The technology used | Advantage | Disadvantage |
|---------------------|-----------|--------------|
| Dual-stack | IPv4/IPv6; dual-stack | simple; mature IPv4/IPv6 coexistence | can’t solve the problem of insufficient IPv4 address space |
| Tunnel | GRE tunnel; 6to4 tunnel; ISATAP; 6PE/6VPE; DS-Lite; 6RD | Effectively solve interconnection of "isolated island"; no loss of information network; maintenance is simple | increase device complexity; not conducive to large-scale applications |
| Translation | NAT-PT; NAT64; IVI; NAT444; BIA; SOCK64 | network maintenance is simple; mutual access between IPv4 and IPv6 | information may be lost; increase the workload of conversion equipment |
Promoting the transition from IPv4 to IPv6 evolution of the Internet, and developing the next generation Internet on this basis has become a global consensus [11]. The transition from IPv4 to IPv6 is a process which needs for a long-term evolution. There will be many IPv4 and IPv6 islands in the transition process. Due to IPv4 and IPv6 is not compatible, we must introduce IPv6 transition technology to achieve conversion of IPv4 to IPv6 [12]. A variety of different approaches have been proposed to solve this problem. The current mainstream transition technology is divided into three types: dual stack technology, tunnel technology and translation technology [13]. Table 1 is a comparison of three techniques. In order to develop a reasonable network transition solution, we should combine the use of the three technologies considering the actual network status.

3. Software Defined Network

In the rapidly changing business environment of the energy internet, the high stability and high performance of the network is not enough to meet the business needs, flexibility and agility is more critical. Distributed energy can be accessed to power grid through many forms, the majority of users can also participate in energy transactions through a variety of network access methods, so flexible network access capability is particularly important. Energy Internet supports a variety of control methods and its operating topology is no longer limited to a specific structure. It is able to achieve independent energy allocation, because its decision unit is no longer restricted by the central control node [14]. In order to meet the development needs of energy internet, the Internet architecture based on software defined network has emerged.

Software defined network is a new network innovation architecture proposed by the CleanSlate research group of Stanford University. Its basic idea is to separate complex control logic that determines how packets are forwarded of the current IP network interconnection node from switches or routers or other equipment, realize the hardware control of the data forwarding rules through the software programming, and finally achieve the purpose of free control of the flow [15]. SDN core technology OpenFlow achieves a flexible control of network flow through the separation of the control plane and the data plane of network device. OpenFlow (OF) is a kind of network exchange model of SDN. Openflow network consists of OpenFlow switch, FlowVisor and controller. OpenFlow switch is used for data layer forwarding. FlowVisor is to make virtualization on network. Controller centralizes control of the network, to achieve the function of the control layer [16].

SDN separates the control power from the network device and administered by a centralized controller. SDN separates control plane and forwarding plane, gets rid of the hardware restrictions on network architecture, and realizes better flexibility and agility of the network. In addition, the programmable ability of SDN has brought the unprecedented flexibility, because the control is completely open, users can customize any network routing and transmission rules strategy.

4. Implementation architecture of business QoS based on SDN

4.1. Existing problems

Fast packet forwarding in data plane and route decision of high level in control plane is integrated together in traditional network technology. The development of this kind of tight coupling mainframe limited the emergence of the IP network innovation technology. Traditional IP packet networks all have the problem which can’t guarantee the QoS, because it is designed to pay more attention to network accessibility and is based on the destination IP address hop by hop routing, it can’t provide QoS bandwidth resources reserved in advance for end-and-end [17].

Large power grid as the energy internet backbone network, QoS is basically no application in its data communication network of our country. Due to the lack of a reasonable QoS planning, many different types of businesses parallel transfer in the backbone data network and influence each other, which has a great influence on the development of the energy Internet data communication network.
4.2. The basic principle of SDN
As the focus of next generation network technology research, SDN defines a new type of network architecture, which simplifies the complexity of packet forwarding rules and separates the control plane from the forwarding plane. The controller in control plane can be centralized management of the switch flow table to achieve the control objective of data forwarding [18]. The decoupling control and forward and centralized control of the network, as well as the controller programming and the flexible control of flow in SDN network provides a good idea for the network QoS planning[19].

OpenFlow is the first interface specification of the open network foundation for the standardization of SDN research system. All versions of the OpenFlow protocol have the description of the support for QoS services. Openflow version 1.3 add meter table the switches, the meter table can’t only test packet forwarding rate, but also control packet forwarding rate. Flow table is the only forwarding rule of the data plane in SDN network, and the flow meter is formulated by the controller and centralized management. So, the controller is the core of SDN network routing control [20].

4.3. Implementation architecture of business QoS
The implementation architecture of business QoS based on SDN proposed in this paper is shown in Figure 1. Compared to general QoS, business QoS is specifically designed for different business to meet their individual needs. We provide different QoS strategies for different service. In this paper, we mainly consider the business needs of the energy internet.

In the proposed architecture, business priority module, network monitoring module and strategy formulation module are deployed in application layer of SDN network. According to the actual situation of the energy Internet and certain rules, business priority module divides and sets the priority of various businesses. Different priorities of the businesses own different bandwidth resources and
transmission flow. Network monitoring module is mainly responsible for monitoring communication network. It can use the controller to check the statistical data on the switch by sending a query message and manage the flow according to the statistical data. Also, it can use OpenFlow switch to collect traffic information, such as sending and receiving data for each port, flow table and queue. Strategy formulation module is mainly responsible for developing the QoS strategy for different business, for example when the queue congestion occurs, the high priority queue should be priority for transmission, or when a communication link fails, how to quickly switch the service.

This paper makes use of queuing mechanisms provided by the OpenFlow protocol to achieve bandwidth guarantee for different types of services. Various services through the OpenFlow access network. The controller distinguishes different types of services by identifying the IP address of the source node, and then the predetermined priority of the services is known. The controller carries on the queuing mechanisms according to the priority of the services. Different priorities of businesses own different bandwidth resources and transmission traffic. OpenFlow switches provide QoS support through such a simple queuing mechanism [21]. Switch port can configure multiple queues. One or more queues can be attached to a port and then be used to forward packets via it. Packets forwarded to a specific queue will be processed according to that queue's configuration (e.g. minimum rate or maximum rate), and control packet forwarding rate of that queue.

5. Research on trustworthy and controllable strategies mechanism
The fundamental purpose of the new network architecture research is to solve the problems encountered in the current energy internet, and to coordinate the contradiction between the growing demand for energy internet applications and the limitations of energy internet technology itself. However, although the design mentality of some new network architecture is good, it can't get practical application because of unable to support incremental deployment. This paper focuses on the research of trustworthy and controllable strategies mechanism for energy internet, and puts forward IPv6 credible network structure transition scheme.

IP network itself tends to be a state of self-control network with high equality. Network itself does not consider the verification of the source address and routing reliability in the basic principle of information transmission, and does not require the service quality. IPv6 network has been fully considered and designed after the long-term development and improvement of IPv4 network, which can provide full support for future network's security, credibility, manageability and controllability. How to realize the IPv6 trusted network needs to be fully considered and designed. IPv6 credible network structure transition scheme is shown in Figure 2, which is divided into four stages.

5.1. IPv6 network control stripping phase
In this stage, the transformation of IPv6 network should focus on the introduction of the control layer to the IPv6 network. Control layer device can be highly customized, and it can design related security guarantee mechanism to ensure the independence of its functions and the compatibility of the original network functions, while ensuring control layer equipment is not hijacked and attacked. Separation of control plane and data plane is the key to the evolution of network, and the basis of the introduction of the definition and reconstruction function in the future. This stage needs to deploy control devices on the network key nodes. Taking into account part network has deployed network equipment which does not support definition function and service deployment and network has been formed, the way of redevelopment can't be implemented, so it is necessary for control equipment not to affect the normal work of the original data transmission service. The new data layer equipment of the key nodes can not only communicate with the control equipment, but also can work with the old equipment, so that the old network can add a control layer and not change the network smoothness.

5.2. Credible phase of access and route
In this stage, the end device access mechanism should be firstly carried on the design and implementation. After the completion of the separation of control and forwarding, the evolution from IPv6 network to IPv6 credible network should start on access credible and routing credible. Identity
authentication device should be deployed in the terminal access side to ensure safe and reliable of the access terminal. And then, the key network nodes require the deployment of two-dimensional routing equipment, introducing two-dimensional routing function in the key nodes on the basis of the compatibility of the original destination address routing policy. In addition, the control interface of the identity authentication device and the two-dimensional routing equipment should be retained to set aside the control interface for the future introduction of control equipment. In order to ensure the authenticity of the information, that is, to ensure the authenticity of the identity ID, we should design the true and credible identity ID address distribution system and authenticity verification system for identity ID based on identity authentication technology.

After the terminal equipment is connected to the network, the IPv6 address is obtained through the address allocation system. The back 64 bits of the IPv6 address assigned by the address allocation system carry the true and trusted identity ID information of the user. The address allocation system registers the assigned IPv6 address with the corresponding true trusted identity ID to the two-dimensional information verification system. After the completion of the access and transmission mechanism, the promotion and transformation of the routing function has been gradually carried in the transmission equipment, and the new routing mechanism has been introduced. It takes the innovative IPv6 source address routing method which is compatible with the destination address routing of the original IPv6 network.

5.3. Network control and partial credible stage

Deploy control devices (such as network virtualization controller) in the access layer, and gradually control the function of the key nodes in the network, to achieve the network key nodes terminal can be abstracted, defined, controlled and reconfigurable. The system administrator can log on the control equipment to make the route definition of the data plane equipment, providing the highly customization, flexible and controllable data forwarding, link definition and Qos guarantee. Deploy trusted transfer functions in the export equipment of the subnet or gateway devices, such as address jump communication module, NAT66 module and so on. Through the design of the gateway equipment function, it can realize the security protection mechanism of the data packet routing transmission and ensure the reliability of the transmission after the end device access and verify the reliable identity. The functional equipment in data layer ensures the credible transmission and completes the established security function through the control device configuration and signaling information. In this stage, the control layer of the network basically has the control authority to main node of the network, and the prototype of the credible network is reached, that is, the main network and key nodes can be managed and controlled, access and routing can be trusted and safe. A credible network architecture based on IPv6 has been initially established.

5.4. Network overall credible stage

After the main network and key nodes can be managed and controlled, access and routing can be trusted and safe, with long-term investment, operation and maintenance, the project will gradually replace the equipment which does not support reliable function in turn, until all the equipment can be controlled and can release control signaling through the control plane, and ultimately achieve the credibility of the whole network.

6. Conclusion

Informatization is a public platform and an important means to support the construction of the energy internet. With the improvement of the intelligent degree of energy internet, many aspects of energy internet will mostly use IP technology in information and communication area. Therefore the construction of the energy internet has put forward higher demand for the controllability and reliability of the information communication network and the IP technology. This paper mainly learns how to use SDN to achieve business QoS to provide QoS guarantee for all energy internet services. In addition, this paper focuses on the research of trustworthy and controllable strategies mechanism for
energy internet, and proposes the transition scheme of the IPv6 credible network architecture based on SDN. It has important reference value for future design of transition strategy from IPv4 to IPv6 network and the research on trustworthy and controllable mechanism for the energy internet, and it provides a reference for the comprehensive construction of safe and reliable energy internet information communication network as well.

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