QoS Deployment in PTN based Power Communication Networks

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***Abstract*—Abundance of applications requires Power Communication Networks (PCN) to provide large bandwidth and QoS guarantee. PTN, the technique trend of future IP transport network, can meet the requirements. In this paper, we present details of QoS deployment in PTN based PCN of Jiangxi province of China. Firstly, QoS mechanisms of PTN are reviewed. Secondly, PCN topology and services are described. Finally, details of QoS deployments in different kinds of nodes, including CoS parameters and bandwidth limitations of PW and tunnel, are presented. Such a deployment strategy can help PTN constructions of other province-level PCNs.**

Keywords-QoS; Power communication networks; PTN; HQoS

I. INTRODUCTION

Power Communication Networks (PCN) are special networks constructed for manufacture, management and sell of power grid. Many kinds of services are transmitted in the networks, including dispatching telephone, video and device surveillance of substation, thunder monitoring, video conference, etc. Since Intelligent Power Grid Project is now driven by Chinese government, more and more intelligent applications will emerge, which raise advanced requirements for PCN. Within these requirements, an important one is to provide differentiated QoS guarantee for different services.

The straightforward way to guarantee QoS is to provide sufficient bandwidth, thus requirements of all services could be meet. However, such an ideal condition is always absent. Therefore, effective QoS strategy is needed. To fulfill QoS requirements of all kinds of services, Power systems are beginning to construct PTN (Packet Transport Network) [1,2,3] or PTN+OTN (Optical Transport Network) based PCN to provide more bandwidth and effective QoS mechanisms.

Currently while SDH/MSTP is the main transport network, ethernet switch and routers play the management role in its independent layer. PTN is a new network proposed by ITU to transport all kinds of IP services [5]. Supporting connection-oriented technique, PTN is considered to be capable of provide multi-service to the operators with a single transport plane. Moreover, PTN is able to maximize the utilization of fiber resources and provide high reliability, automatic resource configuration and flexibility to network environments because it has complete OAM architecture, accurate fault location and QoS classification mechanisms [6]. How to improve the efficiency of operation and maintenance is the most important issue in the front of PTN technology. Whatever, it is the technical trend of next-generation IP transporting network.

Nowadays, PTN is used mainly in 3G/LTE communication system and is rarely adopted by PCN [7]. In this paper, we design a PTN based PCN architecture for power system of Jiangxi province in China and focus QoS deployment issue to accommodate various services of PCN.

The rest of the paper is organized as follows. Section 2 discusses QoS mechanisms supported by PTN. Service analysis of PCN is described in Section 3. Then Section 4 presents details of QoS deployment in PTN based PCN. Finally, Section 5 concludes and points out future work.

II. QOS MECHANISMS IN PTN

PTN supports DiffServ QoS model. When a PTN device acts as DiffServ edge node, it is capable to implement Hierarchical QoS (HQoS) in the node. Figure 1 gives a simplified description on where HQoS mechanisms locate and how they are applied. In a PTN device, there are four QoS levels: *V-UNI*, *PW/QinQ*, *Tunnel* and *Port*.

(1) *V-UNI* level is designed to distinguish different services. At this level, V-UNI Ingress strategy and V-UNI Egress strategy can be created and applied for source and destination services respectively. V-UNI Ingress strategy helps to establish the mapping between service and its corresponding CoS (PHB) and queuing strategy. CoS parameters (include CIR, PIR, etc.) are also determined here. Moreover, at this level V-UNI Group can be created to perform bandwidth control on certain combination of multiple V-UNI.

(2) *PW/QinQ* level locates at network side. A PW/QinQ strategy always matches a V-UNI (if V-UNI group is not created) or a V-UNI group. Bandwidth control can be performed on a PW/QinQ.

(3) *Tunnel* level. A tunnel always accommodates multiple PWs which have the same destination. On each tunnel we can set a differentiated bandwidth limitation.

(4) At *Port* level, services, which are originated from different ingress ports but mapped to the same CoS, is aggregated to share a set of CoS parameters as a whole.

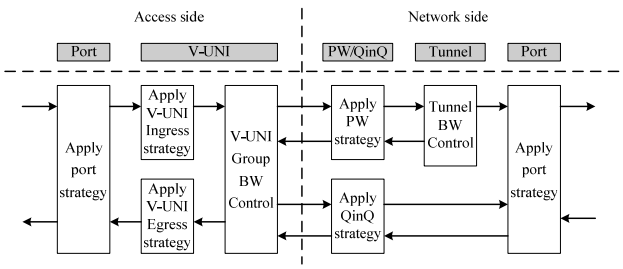

Figure 1. Simplified HQoS framework in PTN

III. PCN TOPOLOGY OF JIANGXI PROVINCE

Figure 2 shows the PCN topology of Jiangxi Province, which combines PTN with OTN. At core layer, there are two OTN core loops which are called southwest and northeast core loops. Under the OTN core layer, there is PTN aggregation layer. Each aggregation loop is connected to a core loop through two PTN devices. Similarly, PTN access loop is connected to PTN aggregation loop. Finally, access nodes, including substation, dispatching center and power plant, are connected to the PTN access devices.

IV. SERVICE ANALYSIS OF PCN

Table 1 shows different services in PCN, which can be classified into four systems: (1) manufacture and dispatching control system; (2) management information system; (3) power sell system; and (4) a system consisting of other services. In this table, RT means real time. The column channel means the channel that the service is transmitted: ① special line; ② dispatching data network; ③ data transmission network.

There are four node types in PCN of Jiangxi province: (1) substations which locate in access, aggregation and core loops; (2) power plants which often locate in aggregation and core loops; (3) dispatching centers (together with electric power companies), including province-level, city-level and county-level. County-level center always locates in access loop. City-level center often locates in crossover of access and aggregation loops. And the unique province-level center locates in the core loop. (4) Administrative offices, managed by province-level electric power company. The following tables describe services which are transmitted between different node pairs.

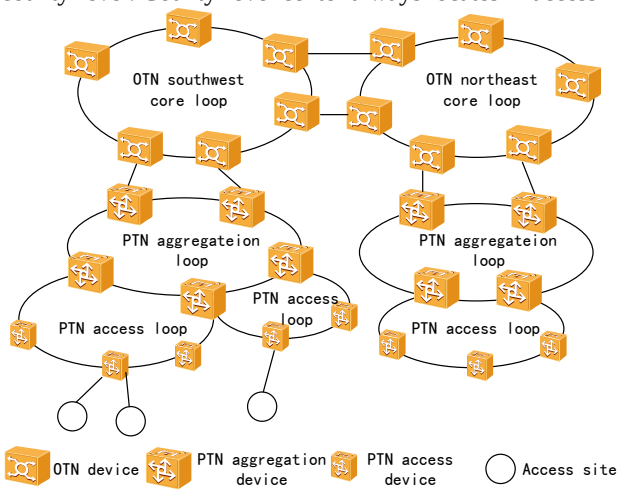

Figure 2. PCN topology of Jiangxi province

TABLE I. SERVICE LIST IN PCN

Service system	Service name	RT?	channel
(1)	Dispatching telephone	Yes	①
	SCADA/EMS	Yes	①
	Dispatching automation	Yes	①
	Running protection management	No	②
	Running safety management	No	②
	Power measuring	No	②
	Power marketing	No	②
	Dispatcher training (DTS)	No	②
	Dispatching management	No	②
	Thunder monitoring	No	③
	Substation video surveillance	No	③
(2)	Financial management system	No	③
	Material management	No	③
	Engineering management	No	③
	Human resource management	No	③
	Safe manufacture management	No	③
	Office automation	No	③
	Administrative telephone	Yes	③
(3)	Sell decision making	No	③
	Sell service management	No	③
	Sell user management	No	③
(4)	Fiber monitoring	No	③
	Transmission running	No	①
	Transmission management	No	③
	Substation device surveillance	No	③
	Cable monitoring	No	③
	Video conference	Yes	①

TABLE II. SERVICES TRANSMITTED BETWEEN SUBSTATION AND DISPATCHING CENTER

Service name	Direction	Traffic
Dispatching telephone	bidirection	2M
Dispatching automation	bidirection	2M
Running protection management	substation -> center	2M
Running safety management	substation -> center	2M
Power measuring	substation -> center	2M
Administrative telephone	bidirection	2M
Substation video surveillance	substation -> center	20M
Substation device surveillance	substation -> center	5M
Thunder monitoring	substation -> center	2M
Cable monitoring	substation -> center	3M
Fiber monitoring	substation -> center	2M

TABLE III. SERVICES TRANSMITTED BETWEEN POWER PLANT AND DISPATCHING CENTER

Service name	Direction	Traffic
Dispatching telephone	substation <-> center	2M
Dispatching automation	substation <-> center	2M

TABLE IV. SERVICES TRANSMITTED BETWEEN POWER PLANT AND DISPATCHING CENTER

Service name	Direction	Traffic
Dispatching telephone	bidirection	2M
Administrative telephone	bidirection	2M

SG-ERP	bidirection	100M
Video conference	bidirection	8M
Transmission running	bidirection	10M
Transmission management	bidirection	10M
Dispatching data network services	bidirection	155M

TABLE V. SERVICES TRANSMITTED BETWEEN PROVINCE-LEVEL COMPANY AND ITS ADMINISTRATIVE OFFICE

Service name	Direction	Traffic
Dispatching telephone	bidirection	2M
Video conference	bidirection	8M
Office automation	bidirection	33M

V. QOS DEPLOYMENT IN PTN BASED PCN

A. *Considerations and principles*

To determine which mechanisms are needed in a certain node, the following factors should be taken into consideration:

(1) How many ingress ports does the node have? Services transmitted in different channels have different ports. Generally, each service transmitted in special line has an individual port. All the services transmitted in dispatching data network or data transmission network share a port.

(2) Which services does an ingress port have? And what are their types, real-time or not?

(3) What are the sender and the receiver of the services?

(4) How many bandwidths does each service require?

In each node, procedures of QoS deployment are as follows:

(1) Establish the mapping between services and CoSs for each ingress port.

(2) Determine parameters of each CoS.

(3) Determine bandwidth limitation of each PW. (We do not aggregate multiple V-UNIs into V-UNI group, but let each V-UNI match a PW)

(4) Establish the mapping between PWs and tunnels.

(5) Determine parameters of each CoS on port level.

B. *QoS deployment details*

QoS mechanisms adopted in different node types are presented in this sub-section.

(1) Substation

Services shown in table 2 are all originated from substation. There are two special line services in each substation: dispatching telephone (denoted as S1) and dispatching automation (S2). The former is real-time voice service and the latter is real-time data service. Both services have a bandwidth requirement of 2Mbps. Running protection management (D1), running safety management (D2) and power measuring (D3) are non-real time data services transmitted in dispatching data network, with 2Mbps bandwidth requirement respectively. The other services are transmitted in data transmission network, among which administrative telephone (T1) is real time voice service and the other are all non-real time data services with different bandwidth requirements.

Table 6 shows details of QoS deployment in a substation (bandwidth unit is Mbps). T2 to T6 denote substation video surveillance, substation device surveillance, thunder monitoring, cable monitoring, fiber monitoring respectively. Column PW means bandwidth limitation of the PW (an ingress port). Since all the services are sent to the county-level dispatching center, tunnel-level QoS deployment is not required. As for port-level QoS deployment, we can aggregate services that originated from different ingress ports but mapped to the same CoS and let them share a set of CoS parameters. Since port-level deployment is distinct after implementing deployments of other level, it is not presented.

(2) County-level dispatching center

Services in this node have two destinations: substations and city-level dispatching center (Generally, power plants are not managed by county-level dispatching center).

If the destination is substation, there are only three services: dispatching telephone, dispatching automation and administrative telephone. Notice that a county-level center may have several substations.

As for city-level dispatching center, services in table 4 are included. Dispatching telephone, transmission running (S3) and video conference (S4) occupy special lines. Administrative telephone, SG-ERP (T7) and transmission management (T8) services are transmitted in data transmission network. Dispatching data network here is responsible for forwarding data from substations to the higher level dispatching center.

Table 7 shows QoS deployment of services in table 4.

Services of dispatching data network from all substations of county-level center are aggregated to the same port. Bandwidth limitation of PW on this port depends on the number of substations.

TABLE VI. QOS DEPLOYMENT OF SUBSTATION

Port	Service	CoS	CIR	PIR	WRED begin	WRED end	Queue	WFQ weight	PW
1	S1	EF	2	2	100%	100%	PQ	/	2
2	S2	AF4	2	4	90%	100%	WFQ	100	4
3	D1	AF3	2	4	70%	90%	WFQ	90	10
	D2	AF3	2	4	70%	90%	WFQ	90	
	D3	AF3	2	4	70%	90%	WFQ	90	
4	T1	EF	2	2	80%	100%	PQ	/	50
	T2	AF2	20	30	70%	80%	WFQ	70	
	T3	AF2	5	10	70%	80%	WFQ	70	
	T4	AF2	2	4	70%	80%	WFQ	70	
	T5	AF2	3	6	70%	80%	WFQ	70	
	T6	AF2	2	4	70%	80%	WFQ	70	

TABLE VII. QOS DEPLOYMENT OF SERVICES IN TABLE 4

Port	Service	CoS	CIR	PIR	WRED begin	WRED end	Queue	WFQ weight	PW
1	S1	EF	2	2	100%	100%	PQ	/	2
2	S3	AF3	10	20	80%	100%	WFQ	90	20
3	S4	AF2	8	20	70%	80%	WFQ	80	20
4	T1	EF	2	2	80%	100%	PQ	/	80
	T7	BE	40	100	60%	70%	WFQ	60	
	T8	AF2	10	20	70%	80%	WFQ	70	

Then let's discuss QoS deployment at tunnel-level. Firstly, all the services sent to the city-level center can be aggregated into a tunnel, including services in table 7 and services from dispatching data network in the above aggregate port. Secondly, dispatching telephone, dispatching

automation and administrative telephone services to each substation can be aggregated into a tunnel. Bandwidth limitations of these tunnels depend on the service distribution.

(3) City-level dispatching center

Services in this kind of node have four destinations: substation, power plant, counter-level center and province-level center. Notice that a city-level center may have several substations, power plants and counter-level centers.

If the destination is substation, services are the same like those in county-level center. And a tunnel can be created for each substation.

If the destination is counter-level center, services in table 4 are included. For each counter-level center, services are divided into several special lines, a dispatching data network aggregation and a data transmission network aggregation. A tunnel can be created for all these services.

If the destination is province-level center, services are divided into several special lines, several dispatching data network aggregations (multiple county-level aggregations and substation aggregations), and a data transmission network aggregation. All these services can be aggregated into a tunnel.

If the destination is power plant, there are only dispatching telephone and dispatching automation services which can be aggregated into a tunnel.

(4) Province-level dispatching center

Services in this kind of node have four destinations: substation, power plant, city-level center and province-level center. Notice that a city-level center may have several substations, power plants and its administrative offices.

If the destination is substation or power plant, all are the same.

Classification of services and QoS deployment from province-level center to city-level center are the same as those from city-level center to county-level center.

If the destination is administrative office, dispatching telephone, video conference and office automation (T9) services are included. A tunnel can be created for each administrative office. Table 8 shows QoS deployment of services in table 5.

TABLE VIII. QOS DEPLOYMENT OF SERVICES IN TABLE 5

Port	Service	CoS	CIR	PIR	WRED begin	WRED end	Queue	WFQ weight	PW
1	S1	EF	2	2	100%	100%	PQ	/	2
3	S4	AF2	8	20	70%	80%	WFQ	80	20
4	T9	BE	15	33	60%	70%	WFQ	60	30

VI. CONCLUSION

In this paper, after analyzing characteristics of services transmitted in power communication networks, we present QoS deployment details of different kinds of nodes, including substation, county-level dispatching center, city-level dispatching center and province-level dispatching center. For each node we implement hierarchical QoS: (1) CoS and its corresponding parameters of each service; (2) bandwidth limitations of PW; (3) tunnel construction principle and its bandwidth limitation. Such a deployment strategy can help PTN constructions of other province-level PCNs.

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