

Approaches to Unification of GPON Broadband Access Service Models for Public Operator's Networks

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Abstract— Currently in regional branches of Rostelecom the different networks architectures from access to IP/MPLS core, different approaches of service layer implementation, and finally, the different service models are used. Approaches to unification of service models are based on customer VLAN (C-VLAN) and they have essential advantages in comparison with service VLAN (S-VLAN). Offered unified broadband access service model has passed benchmark testing and currently in commercial operation for 180 thousands GPON subscribers.

Keywords— Broadband access, service model, GPON, VLAN

I. INTRODUCTION

On Annual General Shareholders' Meeting held on June 26, 2010 the Company's shareholders approved the reorganization made by OJSC "Rostelecom" (Rostelecom). It was made by merging with and into OJSC "CenterTelecom", OJSC "Sibirtelecom", OJSC "Far East Telecom", OJSC "VolgaTelecom", OJSC "North-West Telecom", OJSC "Uralsvyazinform", OJSC "Southern Telecommunications Company". Before reorganization every company had an own broadband access service model.

In this paper the broadband access service model is considered as functional and logical scheme of service providing. This model ensures:

- subscriber and service unique identification;
- subscribers and service traffic isolation;
- quality of services (QoS) differentiation on the L2 of Open Systems Interconnection Basic Reference Model (OSI).

The typical "Triple play" services for broadband subscriber of public fixed network operators are: Video on Demand (VoD) and IP Television (IPTV), Voice over IP (VoIP) and Internet access. These services could be provided by using Virtual Local Access Network (VLAN) planned over xDSL,

xPON, Ethernet, xWDM, Metro Ethernet, IP/MPLS technologies of operators' networks from access to IP/MPLS core [1]. It means that service model is one of the key elements in network development and planning. This model might influence on the unification of service activation, customer premises equipment (CPE) configuration, management, billing, and finally on the network structure.

The main purpose is to create unified service model for joined Rostelecom that could decrease CAPEX and OPEX in network development, caused by broadband subscribers growing.

The service model could be implemented using CPE's like GPON ONT or ADSL modem, access switches like OLT or DSLAM and also access aggregation and service routers (SR) like BRAS, VoIP SR, etc.

II. CURRENT ROSTELECOM SERVICE MODELS

The typical broadband access network architecture of Rostelecom [2] is shown on the Fig.1.

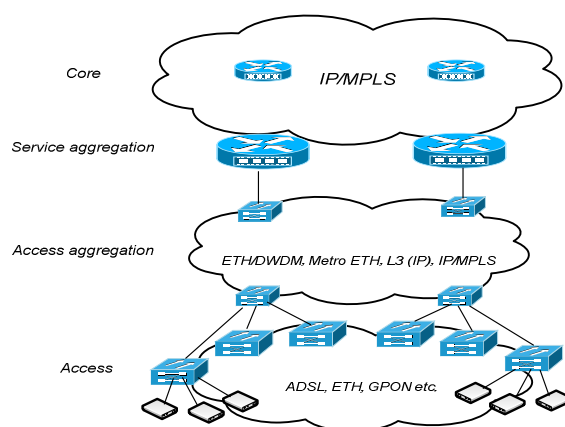


Figure 1. Rostelecom typical broadband access network architecture

IP/MPLS core is based on Juniper, Cisco and Huawei P/PE routers. Service aggregation is mostly based on Juniper and Cisco BRASes and others SRs. Access aggregation layer is optional and implemented using ETH/xWDM, xWDM, Metro Ethernet and IP/MPLS technologies depending on subscribers' density.

The typical broadband access technologies are xDSL, xPON, Ethernet etc., but the target technology is GPON.

Also there are 2 architectural solutions for service layer implementation in Rostelecom (Fig. 2):

1. «specialized» in services splitting into different SR's, usually located in one central office;
2. «universal» with all services combining on every SR, usually these SR's are distributed on the core border.

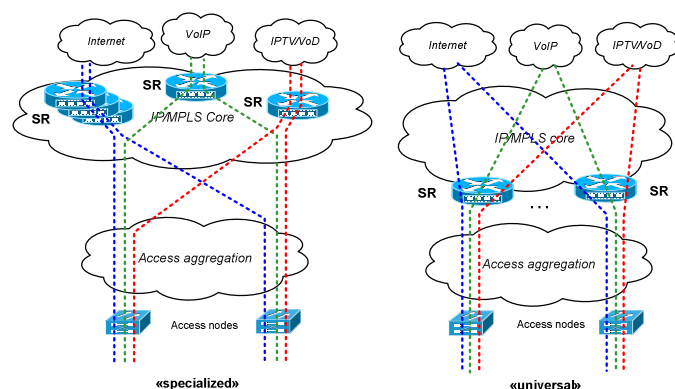


Figure 2. Rostelecom typical service layer architectures

Besides the differences in service layer organization currently in Rostelecom 2 types of broadband access are used with some technology-depending variations (ADSL, GPON, Ethernet):

1. VLAN for service: S-VLAN;
2. VLAN for customer + VLAN for multicast: C-VLAN + MC-VLAN (hybrid model optimized for IPTV)[3].

The key differences of currently used service models are:

- basic methods of subscriber to services logical organization (S-VLAN, C-VLAN or hybrid C-VLAN);
- subscribers isolation methods (C-VLAN or port isolation/split horizon forwarding etc.),

- subscribers identification methods (C-VLAN, Option 82, PPPoE IA, login/password or its combination);
- IP and MAC addresses monitoring and security from subscriber's network intrusions (C-VLAN or DHCP Snooping, Dynamic ARP Inspection, IP Source Guard etc.);
- types of sessions for services traffic transfer (PPPoE, IPoE) and IP-addressing types (IPCP, DHCP);
- CPE modes (switch/bridge for local subscriber's ports and/or router).

The usage of login/password attributes for subscribers identification is risky caused by to CAPEX/OPEX because of Personally Identification Information requirements toughening.

The alternative to login/password method of network identification based of C-VLAN or Option 82/Intermediate Agent is vendor's depending and it needs the simultaneous PPPoE sessions limitation using external OSS/BSS systems.

III. COMPARISON OF SERVICE MODELS

Obviously, that even choice between C-VLAN and S-VLAN service models as a base for creation of universal service model (USM) is a complex problem. To solve this problem the following list of 16 criterions was created by 21 experts (3 experts from each of 7 regional Rostelecom branches):

1. Additional OLT setup for subscribers isolation (Port Isolation, Port-Security, DHCP Snooping);
2. Possibility to select every subscriber traffic on different network layer (OLT/access aggregation/service aggregation);
3. Possibility of subscriber's simultaneous PPPoE sessions for BRAS control;
4. Possibility of automatic subscriber's interface putting into VPN without OLT additional configuration;
5. Possibility to skip «login/password» assignment for PPPoE (identification using VLAN+OLT port combination);
6. Customization of OSS/BSS systems in the case of new types OLT installations;
7. Possibility of separate management, shaping and different subscriber's traffic filtration using service policies on SR interfaces;

8. Necessity to use BRAS for Internet service;
9. Necessity to use BRAS for IPTV, VoIP services;
10. Necessity to support DHCP Option82 on OLT;
11. Necessity to support DHCP Option82 on SR;
12. Necessity to support PPPoE Intermediate agent on OLT;
13. Necessity to support PPPoE Intermediate agent on SR;
14. Necessity to support Q-in-Q on OLT;
15. Necessity to support Q-in-Q on SR;
16. Unification of subscriber's interfaces identification for all services.

For every criterion the local priorities (from 0 to 3) were defined by experts. The priority 3 is merit and 0 is demerit, while 1 and 2 are intermediate estimations (Table 1).

TABLE 1. C-VLAN AND S-VLAN COMPARE

№	C-VLAN	S-VLAN
1	No needed (3)	Yes, mandatory (0)
2	Yes, easily (3)	Yes, using filtration of traffic dump (2)
3	Yes (3)	No (0)
4	Yes (3)	No (0)
5	Yes (3)	Yes, using PPPoE Intermediate agent (2)
6	No (3)	No, using login/password Yes, using DHCP opt.82 and PPPoE Intermediate agent (2)
7	Yes, for all interfaces (3)	Yes, only for PPPoE interfaces (1)
8	Yes (1)	Yes (1)
9	Yes (1)	No (3)
10	No (3)	Yes, using DHCP opt.82, No, using login/password (2)
11	Yes (0)	Yes (2)
12	No (3)	Yes, using PPPoE Intermediate agent (2)
13	No (3)	Yes, using PPPoE Intermediate agent identification (2)
14	Yes (0)	No (3)
15	Yes (0)	No (3)
16	Yes (3)	No (0)
a_i	0,6	0,4

For service model choice the Analytic Hierarchy Process [4] was used (Equation 1).

$$a_i = \sum_{j=1}^N p_{ij} \cdot P_j \quad i=1 \dots M, \quad j=1 \dots N \quad (1)$$

where

p_{ij} - local priority of alternative i for criterion j ;

P_j - priority of criterion j ;

$M=2$ - alternatives C-VLAN or S-VLAN;

$N=16$ - number of criterions.

Based on the presented in the Table 1 result C-VLAN has essential advantages in compare with S-VLAN therefore the unified service model for GPON should be based on C-VLAN.

IV. USM REALIZATION

The following main trends may influence on the principles of USM realization:

- The growth of video-content distribution based on “over-the-top” model, using Internet as a transport and HTTP as a protocol for VoD and TV services over IP;
- Migration of content and Internet resources to IPv6 because of IPv4 addressing exhausting.

Moreover in USM the following target services and their traffic should be considered (Table 2)

TABLE 2. TARGET BROADBAND SERVICES

Service	Transfer direction		Traffic type
	Down [MBit/s]	Up [MBit/s]	
Internet	10	100	Best effort
VoIP	1	1	Guaranteed
MMTel (like Skype)	10	10	Guaranteed
IP TV*	75	-	Guaranteed
VoD*	75	-	Guaranteed
Home network	100	100	Best effort
Local content	100	-	Best effort
Security	0,5	2	Guaranteed
VCoIP	10	10	Guaranteed

* - for 3 HD streams

Taking into account all mentioned above, USM shall cover the following features:

- Isolation and identification of subscribers shall be based on C-VLAN with Q-in-Q stack, consisting of internal ONT-VLAN and external OLT-VLAN identifiers;
- VoIP/VCoIP traffic could be routed to the dedicated VoIP SRs using IPoE sessions, but all other unicast traffic (Internet IPv4/v6,

IPTV unicast, VoD etc.) shall be routed to BRAS;

- ONT shall support IPv6 addressing;
- IPTV multicast shall be transferred to OLT using MC-VLAN in IPoE session via access aggregation layer equipment or via BRAS directly connected to OLT.
- Based on benchmark testing results [5] for ONT configuration using TR-069 protocol the

common S-VLAN between OLT and BRAS shall be created.

Thus, the hybrid service model is used for GPON access. This hybrid service model (Fig.3) implementation means S-VLAN (GEM ports) usage between ONT and OLT, C-VLAN and MC-VLAN between OLT and SRs (BRAS и VoIP SR).

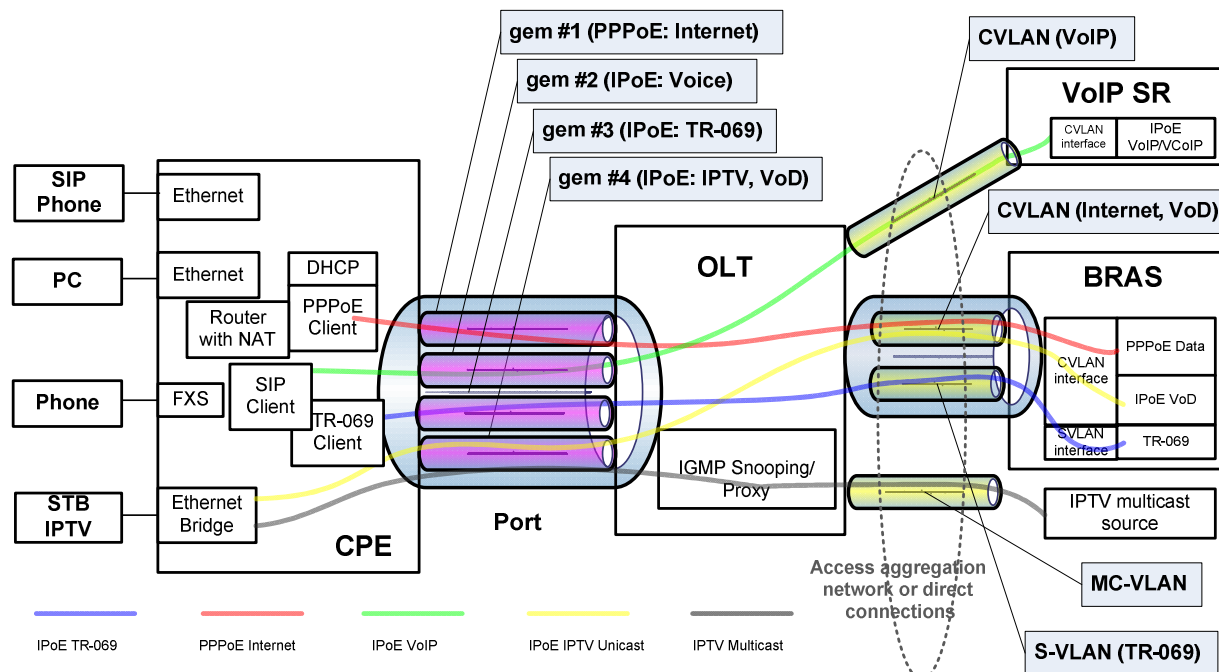


Figure 3. Logical structure of USM for GPON

These GEM ports between ONT and OLT are created for every service (or group of services):

- GEM Port (VoIP) – for VoIP/VCoIP traffic;
- GEM Port (PPPoE) – for Internet IPv4/v6 traffic;
- GEM Port (TR-069) – for auto configuration using TR-069 (CWMP) traffic;
- GEM Port (IPTV) – for IPTV and VoD traffic.

ONT is operating as a router and “bridge” simultaneously depending on subscribers’ Ethernet local interfaces configuration.

Other VLANs are created based on the mentioned above principles. The dedicated MC-VLAN for IPTV multicast traffic transfer is the common for all subscribers of every OLT.

V. THE WAYS OF MIGRATION TO USM

Currently on regional network of North-West branch of Rostelecom the VoIP and Internet traffic is served by BRAS (Fig.4).

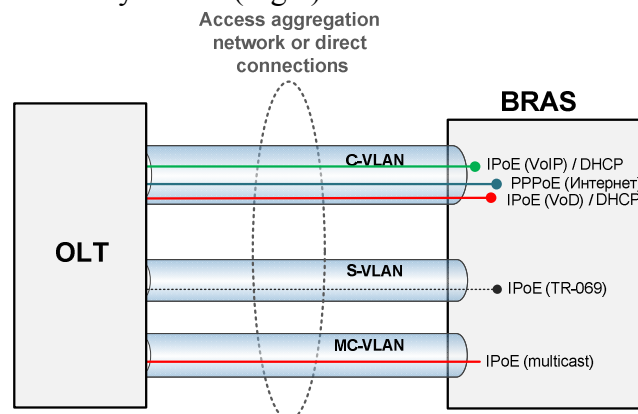


Figure 4. North-West branch of Rostelecom service layer architecture

On every subscriber's C-VLAN interface of BRAS created several subinterfaces: one PPPoE and two IPoE. In the current solution BRAS provides the services traffic processing with the different requirements of availability and reliability because the unicast traffic processing of VoIP, VoD and Internet services, and multicast traffic of IPTV service provided by universal SR - BRAS.

This approach is reasonable on initial stage of VoIP service deployment when amount of subscribers is small because dedication of special VoIP SR is not economically reasonable.

The growth of VoIP and VCoIP subscribers' amount could be condition for this service model final transformation to USM.

Finally to complete migration to USM is necessary to provide:

- multicast traffic transfer to OLT using access aggregation layer equipment;
- separate processing of VoIP/VCoIP unicast traffic on dedicated VoIP SR.

VI. CONCLUSIONS

Current North-West branch of Rostelecom approach putted into commercial operation for more than 180 thousands GPON subscribers.

Comprehensive benchmarking of other migration ways to USM would be provided in 2Q of 2012 г. on the specially created trial zone.

Unified technical solutions like USM for merged OJSC Rostelecom can provide:

- CAPEX optimization for networks development;
- OPEX optimization by decreasing expenses for technical support, staff, powering, estate fees;
- Simplification of relations with vendors;
- Decreasing the time to start for new services.

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