

A Multi-Wireless Bandwidth Aggregation Mechanism in SDN Networks

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Abstract: Nowadays, the popularity of smart mobile devices drives the mobile data traffic into a faster growth. For handling the extreme growth of mobile data traffic, the mobile telecommunication operator tries to upgrade the core network equipment to expand the data capacity of services, but compare with the exponentially growing mobile data traffic, the effect is limited. In addition, most of the current multi-RAT integration researches need protocols supported by both the clients and servers, or have the transmission efficiency bottleneck problem caused by the packet reordering. Therefore, this paper proposes the SDN-based multi-RAT bandwidth aggregation mechanism for handling the transmission path selection and switching among LTE, Wi-Fi, and other multi-RAT. The proposed multi-RAT online access software, aggregation control application, and data flow analysis application are installed in the UE terminal and SDN network terminal respectively for handling the multi-RAT bandwidth aggregation. The UE only needs to install the multi-RAT online access software through the proposed mechanism, while the application services executed in the UE terminal do not need to be modified under the proposed approach. When a single network could not satisfy the QoS requirements of UE (e.g., the UE executes several application services which require different QoS classes simultaneously), the proposed SDN-based multi-RAT bandwidth aggregation mechanism can transmit the routing device, satisfy the network QoS requirements of the UE terminal and improve the utilized efficiency of whole network according to the current network transmission efficiency and the characteristics of the service flows transmitted by the UE.

Keywords: Multi-RAT bandwidth aggregation; network selection and switching; Software-Defined Networking; QoS class.

1. INTRODUCTION

Nowadays, the popularity of smart mobile devices drives the mobile data traffic into a faster growth. Compared with last year, the global mobile reports published by the telecommunication manufacturer Ericsson point that the users of the global mobile phones and the mobile bandwidth users have increased 7% and 40% respectively in the third-quarter in 2013. The users will over 2 billion this year. The data flows of the users may have increased 80% compared with last year and it will increase ten times in 2019. For handling the extreme growth of mobile data traffic, the mobile telecommunication operator tries to upgrade the core network equipment to expand the data capacity of services, but compare with the exponentially growing mobile data traffic, the effect is limited. The Mobile Data Traffic Offloading technology proposed by the mobile telecommunication operator, such as the Wi-Fi Offloading [2], can temporary disperse the mobile data flow, but it cannot meet the requirements of the mobile data flow of the signal mobile device which is gradually increased for a long time. Most of the smart mobile devices are installed multi-network interface, such as the HSPA, the LTE and Wi-Fi. Therefore, the integration of the multi-RAT is a feasible solution for satisfying the flow offload and the requirements of the service quality of transmitting the data in the mobile network users.

The Multi-RAT Bandwidth Aggregation adopts the features of the multi-RAT interface of the mobile devices (can also be called as User Equipment) to do the optimal network device for the multi-RAT interface according to the current situation of using the network. In this way, the requirements of the Quality of Service of the multi-applications of in UE can be satisfied and the using rate of the networks can be improved. In addition, there is the centralized tendency for the network online device and the management, such as the Software-Defined Networking technology. The control function in the switch can be centralized on the controller managed by the center.

The controller can carefully control the online in each switch with the Open Flow protocol. For example, which switches needed to be passed through a signal online transmitted route for ensuring the optimal transmitted quality can be decided.

The multi-RAT bandwidth aggregation based on the SDN is proposed in the paper. When a signal network cannot meet the requirements of the QoS of the UE (such as the UE can simultaneously conduct many application services of different class service quality), the proposed multi-RAT bandwidth aggregation based on the SDN can control it and the service flow can analyze the system. The OpenFlow Controller can provide the transmitted route device decision of transmitting the optimal efficiency by the OpenFlow Switch in terms of the transmitted efficiency of the current network and the service flow features of the UE. In addition, it can also adopt the OFS to do the wireless network bandwidth aggregation for satisfying the requirements of the net-

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work service quality in each UE (for example, different application services can adopt the network interface with different service quality to do the data transmission). Furthermore, the network transmitted efficiency in the UE can be accelerated and the using efficiency of the whole network can be improved.

2. REFERENCES DISCUSSION

The researches about the multi-RAT integrated system are just in the phase of the feasible discussion and the researching analysis. The following contents will be discussed in terms of the network protocol.

The XFTP [3] and the GridFTP [4] can obtain all available network interfaces in the Application Layer. The proposed method can disperse all transmitted data to each interface for being transmitted simultaneously.

The advantage of the proposed method is that the features of the applied services can be completely controlled so that the data can be divided in detail and the transmitted efficiency in the individual application services can be optimized, while the complexity of the application layer can be increased and the transmitted method should be compromised with the application service. What's worse, the problem of the head-of-line blocking may be caused. When it is transmitted in the transmission layer with the TCP protocol, the latter packets can be solved after the lost packets have been re-transmitted under the condition of happening the lost packets. In this way, the delay of the data transmission can be caused.

Multipath TCP (MPTCP) [5] adopts the online with multi-transmitted layers to transmit the data in the application service. Its advantage is that a more reliable multi-route transmitted service can be provided in the TCP protocol, but the method should be compromised with the network framework based on the TCP. If the receiving & delivering terminals need to support the protocol and just support the data transmission in the TCP protocol, the inconvenience of the usage can be caused.

The WRR [6] is the IP packet from each transmitted layer session in the Network Layer, and should be transmitted by different network interfaces. Its advantage is that there is no difference to the upper layer application and it can be compatible with the present basic network framework. As the packet arrival time in each network is different, the dislocation of the packet order can cause that the transmitted packet in the TCP protocol should be continuously initiated and re-transmitted. In this way, the network transmission speed can be reduced so that the packet reordering should be conducted when the packets are received. When the number of the packet transmission is large (each second is above 1 G bite), the serious reduction of the network transmitted speed can be caused because the received terminal of the packets can not conduct the packet reordering.

The LACP [7] combines many physical links into a logical communicated links in the Data Link Layer for improving the use rate of the bandwidth after being integrated.

The technology should be finished with the special soft & hardware's and has the problem of the packet reordering the same as the deed of the transmission layer.

In addition, the above proposed researches cannot conduct the optimal dynamic adjustment of transmitting the paths aiming to the load state of each network. The multi-RAT bandwidth aggregation control based on the SDN and the system of the service flow analysis are proposed in the paper. The transmitted path device whose transmitted efficiency is the optimal can be conducted in terms of the features of the current network transmitted efficiency and the service flow in the UE for meeting the requirements of the QoS in each UE, accelerating the network transmitted efficiency in UE and improving the use rate of the network service quality. In this way, the shortcoming of the current international technologies can be compensated, the industry institute designed plan can be assisted and the feasible researching analysis can be provided to the development of the related core technologies.

3. SYSTEM FRAMEWORK

The SDN network framework between the back-end network (such as the Mobile Core Network, the Mobile CN and the Internet) and the wireless base station (such as the LTE HeNB and the Wi-Fi AP) can be imported to do the network online configuration, as shown in the Fig. (1). The OFC collects the real-time load information from each wireless base station for connecting with the requirements of the QoS of the UE in each wireless base station. The network online in each OFS can be controlled through the OpenFlow protocol for reaching the target of the multi-RAT configuration and the bandwidth aggregation. A Multi-RAT Adapter should be installed in the UE and offer a virtual interface to the application service storage. Then the application service packets received from the virtual network interface should be transmitted according to the current transmission rules which are changed into the physical multi-RAT interface (such as the LTE and the Wi-Fi interface). The MRA can communicate with the Aggregation Control Application (AC App.), Flow Analysis Application (FA App.) in the OFC for obtaining necessary information during the process of the network online switch and the aggregated transmission. The AC App. and the FA App. should be give an order or obtain the information by the OFC API controls the OFC to finish the multi-RAT bandwidth aggregation and the network packet routing.

As the OFC just can retrieve or exchange the header of the general network packets and cannot remove or increase the segments of the packet header, the GPRS Tunneling Protocol tunnel in the LTE network should be managed by the proposed Local Gateway. The LGW is the passageway of the GTP packet in the LTE HeNB, and the management method of the GTP tunnels is divided into two layers, the GTP Control [8] and the GTP User [9]. The GTP-C packet is mainly in charge of the addition, the updating and the deletion of the tunnel, while the GTP-U packet mainly carries the data of users. Its carrying method is that the GTP-U header is added

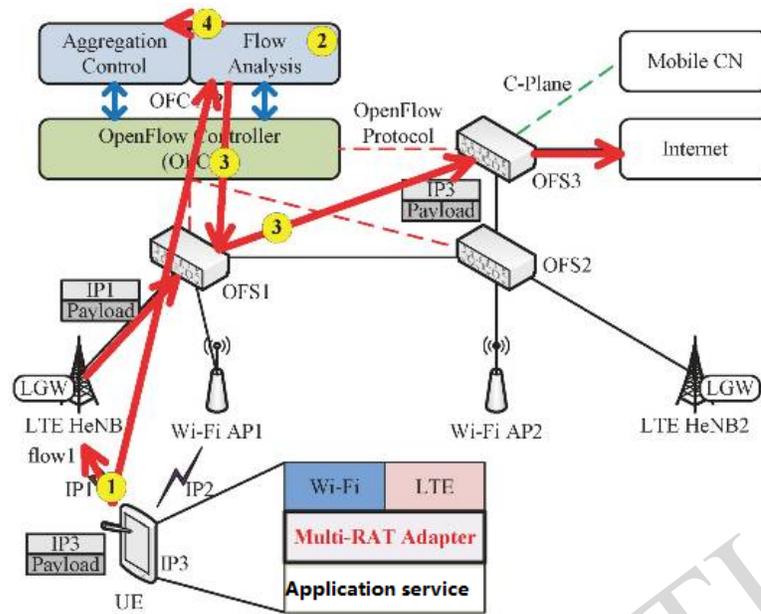


Fig. (3). The step 1 to 4 in the multi-RAT bandwidth aggregation mechanism based on the data flow.

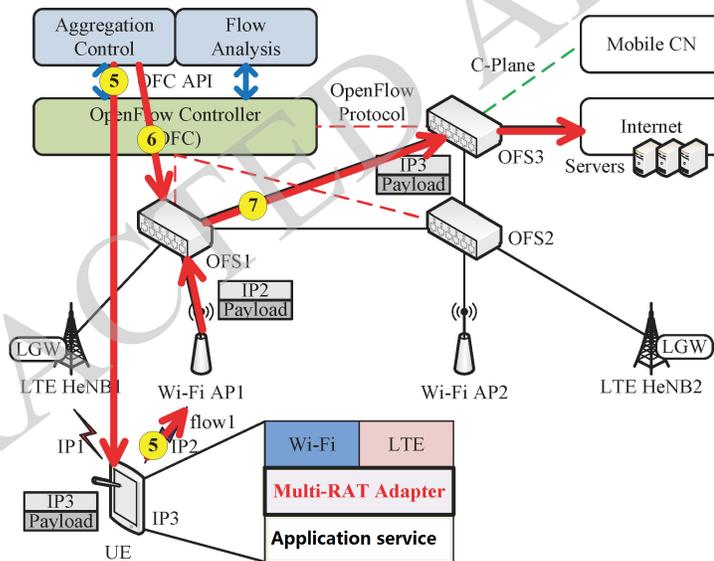


Fig. (4). The step 5 to 7 in the multi-RAT bandwidth aggregation mechanism based on the data flow.

Step 1: UE connects the LTE network to obtain the IP1, connecting the Wi-Fi to obtain the IP2 and presetting the LTE as the transmitted network.

Step 2: The MRA of the UE sends the registration request to the AC App through the LTE network for registering the network interface information (LTE=IP1, Wi-Fi=IP2).

Step 3: The AC App. Records the network interface information of the UE. The information decides the aggregation point as OFS1 and configures the IPS to UE for providing the application service to use of the external communication.

Recording format: UE ID (ex: IP3)/ UE IP1/ UE IP2/...

Step 4: The AC App. Transmits the registration response which includes the IP3 to the UE.

Step 5: After the MRA of the UE sets the IP3, the initiation of the multi-RAT can be finished.

4.2. The multi-RAT bandwidth aggregation mechanism based on the data flow

The multi-RAT bandwidth aggregation mechanism based on the data flow is as shown in the Fig. (3) to the Fig. (5), and its steps are as follows:

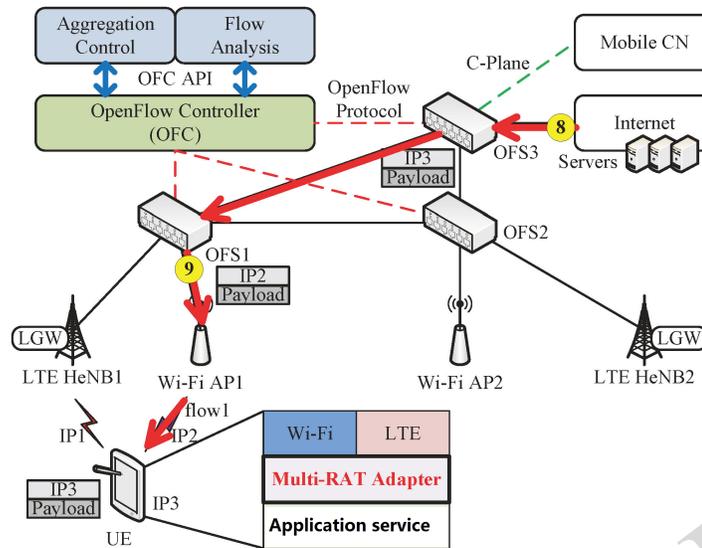


Fig. (5). The step 8 to 9 in the multi-RAT bandwidth aggregation mechanism based on the data flow.

Step 1: The UE initiates the new service flow1 and then the flow1 information should be transmitted to the FA App. The interface IP between the LTE and the Wi-Fi in UE is respectively IP and IP2 for making the UE communicate with the OFE. If the UE adopts the LTE to transmit the flow1, the MRA will change the Source IP (SrcIP) into IP1.

Information format: UE ID (ex: IP3)/ Source Port# (SrcPort)/ Destination IP (DstIP)/ Destination Port# (DstPort)/ Protocol (如 TCP、 UDP)/ Service Name. If the value of the segment is NULL, the segment can be ignored.

Step 2: The FA App. can periodically collect the remaining bandwidth information in each network. After the flow information is received, it can be compared with the service database.

Step 3: If the comparison of the FA App. has no results, the corresponding Action should be established in the OFS and the packet data of a flow1 should be retrieved to analyze its service type after the FA App. receives the packet in information of the flow1 (SrcIP=IP1 and SrcPort=flow1).

- Action1: Convert the IP3 in the SrcIP of the flow1 downlink packet into the IP3, and the IP3 packet routing method should be established.

- Action2: Convert the IP1 in the DstIP of the flow1 downlink packet into the IP1, and the corresponding network in terms of the DstIP should be transmitted back.

- Action3: The uplink and the downlink of the flow1 should be copied to transmit back to the FA App.

Step 4: After comparing or analyzing the FA App, the service types of the flow1 can be obtained. The transmitted network of the flow1 (such as the Wi-Fi) should be decided according to the service types, the features of each network and the matching of the remaining bandwidth information.

The decision results should be transmitted to the AC App and the related information of the flow1 should be recorded.

The recording format: UE ID (ex: IP3)/ SrcPort/ DstIP/ DstPort/ Protocol/ NetID (ex: IP2). If the value of the segment is NULL, the segment can be ignored.

Step 5: After the AC App. receives the decision from the FA App., the UE should be noticed to transmit the flow1 with the decision network.

Notice format: UE ID (ex: IP3)/ SrcPort/ DstIP/ DstPort/ Protocol/ NetID (ex: IP2). If the value of the segment is NULL, the segment can be ignored.

Step 6. AC App. In OFS modify the corresponding Action.

- Action1: Convert the IP2 in the SrcIP of the flow1 uplink packet into the IP3, and the routing method of the IP3 packet should be established.

- Action2: Convert the IP3 in the DstIP of the flow1 downlink packet into the IP2, and the corresponding network in terms of the DstIP should be transmitted back.

- Action3: Delete the Action copying the packets in the uplink and the downlink of the flow1 to the FA App.

Step 7 The UE adopts the Wi-Fi network to transmit the uplink packets of the flow1, and the OFS will transmit the uplink packets of the flow1 to the Internet servers.

The OFS converts corresponding network interface transmitted packets into the data flow of the IP3 (allowing the data flow to do the interface switch) , and then it should be transmitted into the Internet.

Step 8: The Internet Servers should transmit back to the downlink packets of the flow1 in the UE (DstIP =IP3).

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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