

SDN-based heterogeneous network architecture with Multi-Controllers

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Abstract— This paper presents a proof-of-concept software-defined networking (SDN) based on Multi-controller for heterogeneous wireless networks, which can be helpful for researchers. There is limitation in the design of the existing architecture of the controller to manage the messages generated from the user equipment (UE). Our proposed architecture has more flexible and scalable through the hierarchical structure of Multi-controller and the loosely-coupled heterogeneous networks. In this paper we present the procedure of handover scenario using proposed architecture.

Keywords— SDN, Multi-controller, Heterogeneous network, Loosely-coupled, Handover procedure

I. INTRODUCTION

SDN based Multi-controller is a fundamental approach in SDN architecture. Traditional single controller architecture has architectural limitations in managing the entire network [1]. Multi-controller has a faster response speed and a more flexible network structure. The SDN controller uses the OpenFlow protocol [2] to communicate with existing switches to manage the networks continuously. However, the performance of a single controller has limited capacity due to the limitations of controller hardware performance. As a result, it is difficult to respond quickly to the demands of an enormous increase in devices. For example, in [3] most SDN controllers have a limited number of flows per second that can be accommodated by the SDN controller. Besides, the performance of the SDN controller is different. In the case of the large-scale network, this problem is apparent more obviously. Also, Problems with the single SDN controller has broken can cause problems with the entire network.

There are mainly two methods to use the Multi-controller approach. It is divided by how the SDN controller is deployed, the first method is flat, and the other is a hierarchical approach. HyperFlow [4], is an example of flat method, whereas, Onix [5], and Kandoo [6] are examples of hierarchical design.

Figure 1 represents the structure of the flat method. This structure has less processing on controller side than a single controller, but requires additional control overhead for integrated management of the controllers. The problem between the nearest local controller is easy to solve, but it takes more time for a remote Local controller. To solve these problems, we propose a way with a hierarchical structure.

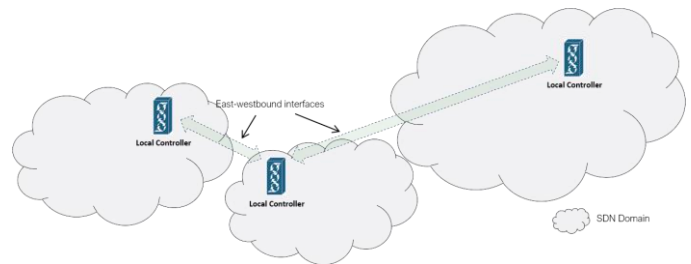


Figure 1. Basic SDN Multi-controller flat placement

Figure 2 represents a hierarchical structure. The hierarchical structure is a controller that uses two layers. The Global controller has holistic topology information, and the Local controller has local topology information. Local controller aggregate problems or information that occurs within the region, and this information solves problems within the region managed by the Local controller themselves.

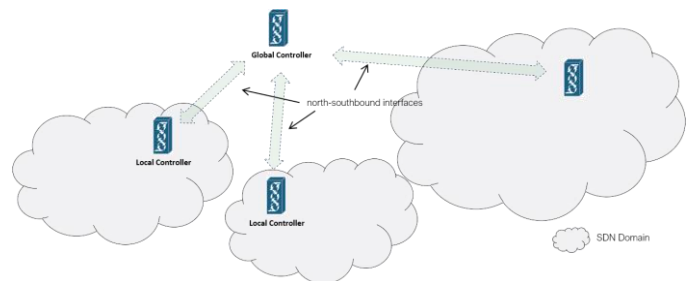


Figure 2. Basic SDN Multi-controller hierarchical placement

In the traditional heterogeneous networks has several problems. The coupling structure between 3GPP-based LTE and WiFi requires a separate gateway [7]. This structure has difficulty providing scalability and flexibility for the entire network.

Figure 3 structure is possible because the SDN controller has a global network view. This structure is possible to reduce costs because it does not require a separate gateway.

In this paper, we focus on the design of the Multi-controller loosely-coupled architecture in heterogeneous networks. We expect that the proposed structure will have a more scalable and agile structure than a single controller.

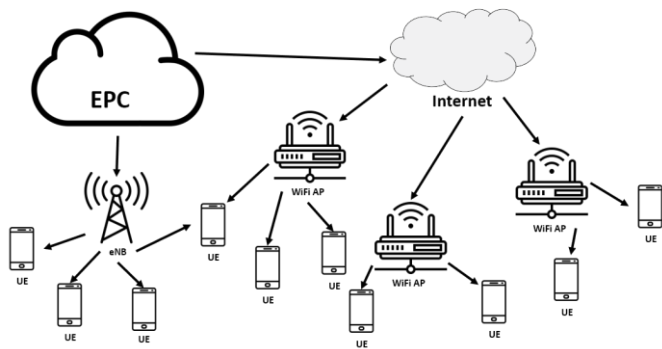


Figure 3. LTE and WiFi interworking structure with Loosely-coupled connections

The rest of this paper is organized as follows. Section II presents our architecture with the handover procedure. Finally, we conclude the paper in Section III.

II. DESIGN OF MULTI-CONTROLLER ARCHITECTURE

The LTE and WiFi interworking structure using the Multi-controller suggested in this paper is shown in Figure 4.

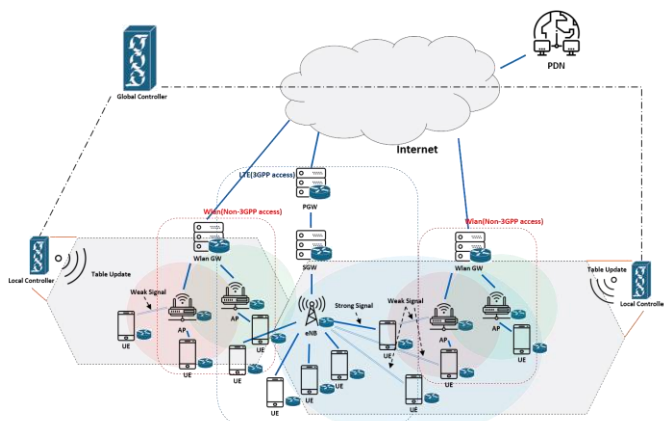


Figure 4. LTE and WiFi interworking structure with Loosely-coupled connections with Multi-controller

In the proposed structure, the Global controller is located at the highest level. The Global controller controls the Local controller and the overall network structure. And each Local controller manages a small area of SDN, which has a loosely-coupled over the Internet. The Local controllers are present at location levels, such as eNB and AP. At this point, the Local controller resolves the requests that occur in their regions themselves. If a different Local controller is needed, ask the Global controller, and the Global controller solves the problem. This structure allows the Local controller to be in a low position, which solves the problem at a rapid response rate.

99.70% of the control messages are generated by the SDN controller are messages (Packet-In/Out, State-Request/Response, Flow-Modify/Removed) to change the Flow Table [8]. Flow Table change messages are generated when a path change occurs. The path change occurs when the UE changes the network when the location is changed. In this

case, it is very significant how to change between networks. We will discuss the handover in the next section.

A. Handover procedure

In the structure proposed in this paper, two main handover approaches are proposed. The first is Handover using a Global controller. The second is Handover using Local controller Only. When the handover between LTE and WiFi in the Local controller area is called the Inter handover, and in this case, a global controller is not required. In this case, it is possible to handover very quickly and at a low cost because it can be handover without the need for PGW or WLAN GW. The UE is handover from the Local controller to another Local controller, which requires a handover using the Global controller because the local controller does not know the information of the other Local controllers. This handover called Intra handover. This handover case delay is slow because it needed several steps for communication between the Local controller and The Global controller.

In the usual case of handover, we suppose to handover from LTE to WiFi. The UE typically use LTE and connect when they can connect to WiFi. That is why this paper explains the case of handover from LTE to WiFi.

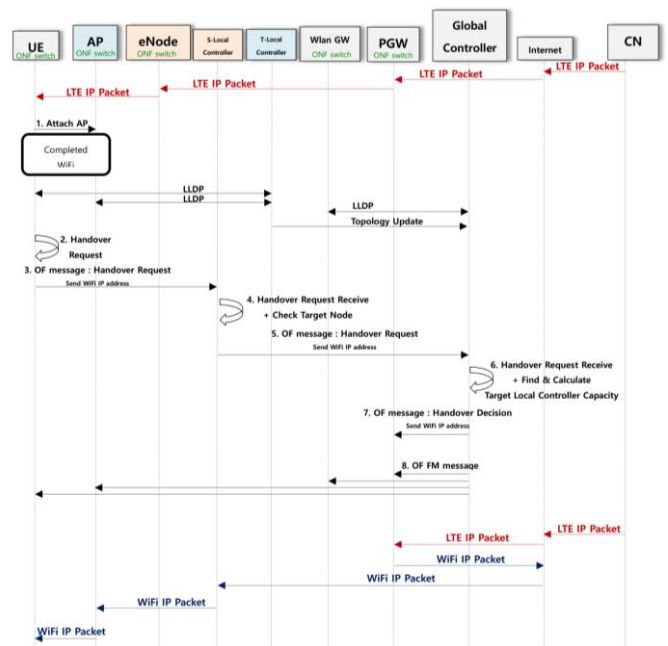


Figure 5. LTE to WiFi handover using a Global controller

Figure 5 describes the handover strategy from LTE to WiFi that uses the Global controller. The strategy of using Global controllers is described as follows: First of all, when the UE passes through the WiFi area and basically connects to the AP, the existing authentication structure or security-related parts when connected to the AP follows the method of the traditional network. After the connection is completed, the UE and the AP switch connect to the Local controllers and the switch of WLAN GW will have a TCP connection with the Global controller. The Local controller then sends updated

topology information to the Global controller. The switch of the UE is a handover trigger request to the S-Local controller, and the S-Local controller is to send a handover request to the Global controller. When the Global controller makes a handover decision, the Global controller informs the PGW switch that the UE is handover to the WiFi network of the T-Local controller and provides the address of the WiFi. The Global controller directly modifies and adds Flow Table information for UEs, AP, WLAN GW, and PGW via OpenFlow Flow Mod messages. The UE receives packets coming back over the Internet. This data has a WiFi IP address, but is changed back to the LTE packet from the switch of the UE, and the application can receive the LTE data packet.

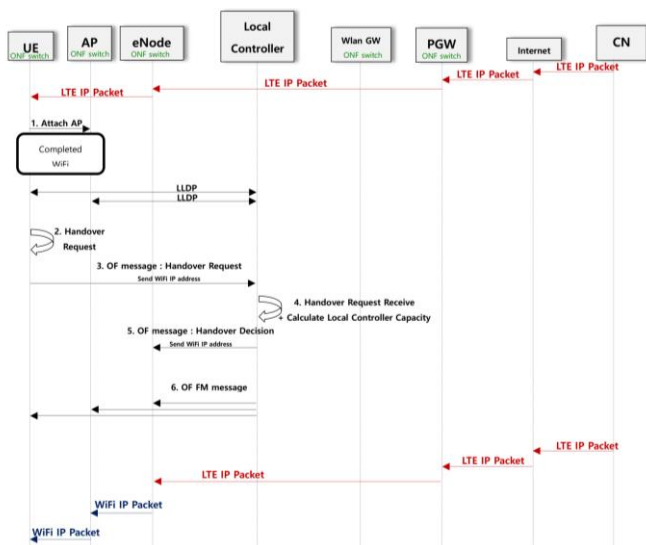


Figure 6. LTE to WiFi handover using Local controller Only

Figure 6 describes the handover strategy from LTE to WiFi that uses only the Local controller. This method is located very close to the UE, unlike the existing method of the Local controller can quickly respond to the request of the UE because it manages a smaller network.

The handover strategy proposed in this paper can be described as follows: The way the UE connects to the AP is the same as the method described earlier. And the handover request is a handover trigger request to the Local controller directly to the switch of the UE. At this time, the switch is also transmitted with information about the WiFi address. The Local controller decides whether or not the UE handover through the network information received from the UE. When the Local controller decides to do a handover, the Local controller notifies the eNB switch that the UE is moving to WiFi and also provides an address for WiFi. The Local controller sends OpenFlow Flow mod messages to the UE, AP, and eNB. Each switch changes the Flow Table due to the flow mod message received. LTE data through the changed data path is to send packets directly from the eNB to the AP. The data is sent over WiFi to the UE with very short latency. UE will receive the LTE packet in the same way as the strategy described earlier.

III. CONCLUSIONS

This paper explained the structure of the Multi-controller and its handover strategy. The proposed structure has a hierarchical structure, which makes it possible to have a flexible and agile structure compared to a single controller. In addition, it has a loosely-coupled structure, which is flexible in structure and reduces costs because the extra gateway is not required for the connection between networks. We can predict that our proposed structure is more efficient than a single controller. Our next task is to evaluate the performance of the proposed architecture and the actual commercially available SDN controllers and simulations.

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