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Mobile Management Method for SDN-Based Wireless Networks

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Abstract: The present Software-Defined Network (SDN) can cause the exchange of the SDN information and the action of the reconfigured by the routed rules during the handovers of the UE so that the procedure of switching the AP can increase the extra delay. The degree of the delay caused by the action depends on the scale of a network and network conditions at that moment, which could be more than 1000 mini-seconds. Therefore, the service quality can be degraded. In order to reduce the influence of the switching delay by the SDN information, this paper proposes a mobility control method for SDN-based wireless networks, whose concepts of the zone and the pre-configured routing rules are utilized in the proposed method to enable the function of routing the up-link packets. In addition, an on-line trigger design is proposed to proactively trigger a SDN information to the SDN controller so that the down-link routed routing can be updated. After the SDN controller receives the information, each AP and the routed rules are just required to be adjusted without re-configuring the routed rules so that the time of re-configuring can be reduced. The above two designs can reduce the delay of switching the AP affected by the SDN information and accelerate the handover of the UE.

Keywords: Software-Defined Network, SDN, Mobility Management, MM, Wireless, network.

1. INTRODUCTION

The SDN has become a hot issue since 2012, but the SDN is not a necessity of people's livelihood for many networks can also operate well without it. A common point is the service orientation in terms of the related applications of the hot clouds, such as IaaS, PaaS and SaaS. The SDN is very fit for the wireless networks whose users can usually move for its controlled management and the network routed behavior can be dynamically adjusted. Moreover, a more effective AP service can be provided according to the situation of using the networks. It is necessary for the SDN to offer the programmed service scheme and the scaled request in terms of the actual required network's situation. In addition, the angle of the service can drive the environment required by establishing the networks. The current network concepts can not support the concept of the service driven by the network-based infrastructure framework.

At present, the AP and the switch can support the function of the SDN, while there are still the improved spaces supporting the mobile management by the current wireless SDN network. When the UE moves to change the AP, there is a problem of increasing the handover delay. The handover procedures of the current SDN network must include the exchange of the SDN information and the increasing of the handover delay. If the time of exchanging and handling the SDN information is among the 3ms~1000+ms, the base station and the back-end switch can not route the packets for the UE before configuring the data routing. What's worse, there is severe packet missing.

The routed rules of all APs and switches is appointed by the SDN Controller, as shown in the Fig. (**1**). After the UE is handover to the Target AP, the routed rules must be adjusted by the SDN Controller when the Target AP has no routed rules of the UE. In addition, the handover delay can be extra increased. Therefore, the paper aims to solve the problem of increasing the handover delay so that the short of supporting the mobile management by the SDN networks can be compensated.

The following chapters are as follows. The second chapter introduces the related researches, including the OpenFlow and the mobile management mechanism. The OpenFlow is an important standard of achieving the SDN which can make the central controller communicate with the network equipment with the OpenFlow function. The third chapter explains the proposed mobile management method. The fourth chapter conducts the technological comparison. The fifth chapter makes a conclusion.

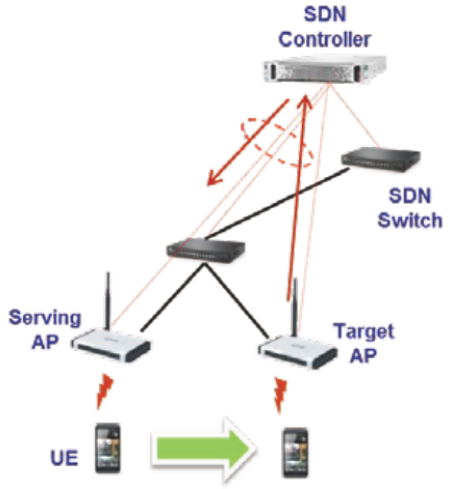

Fig. (1). The handover delay of the SDN network.

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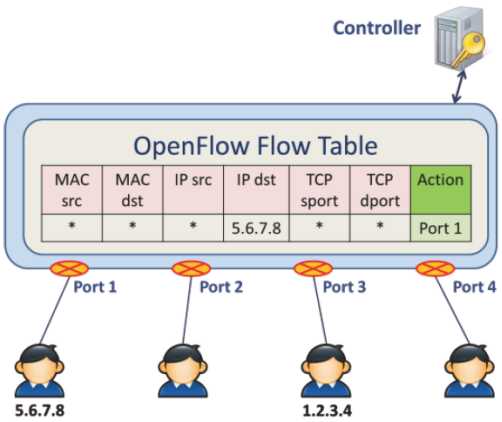

Fig. (2). The framework of the SDN.

2. RELATED RESEARCH

2.1. The Introduction of the OpenFlow

The switches in the network can establish the routed rules and determine the routed behavior of its packet through the control of the SDN Controller, as shown in the Fig. (**2**). The routed behavior in the switch is decided by the packet Flow Entry in the packet Flow Table. In other words, the packet Flow Entry defines the routed rules of the switch. For example, when there is a routed rule in the switch where the destination IP is 5.6.7.8 and be sent to the port 1, the terminal whose IP address is 1.2.3.4 can send the packet to the terminal whose IP address is 5.6.7.8. While the terminal whose IP address is 5.6.7.8 without any suitable rules can not send the packet to the terminal whose IP address is 1.2.3.4. As all rules are determined by the SDN Controller, the SDN Controller can change the routed behavior of the switch at any moment.

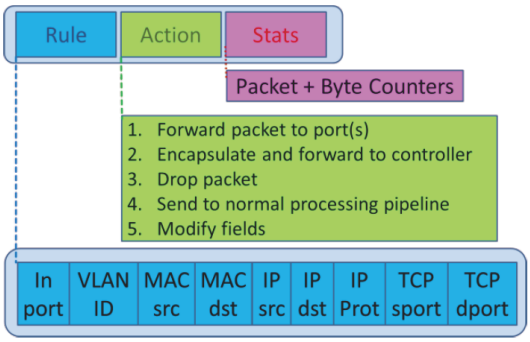

Fig. (3). Flow table entry format.

The switch can know how to deal with the packet according to the packet of the MAC address, IP address, TCP port and VLAN ID, as shown in the Fig. (**3**). The handling methods include the following procedures, routing the packet to an Output Port, re-sending the packet to the SDN Controller, dismissing the packet and changing the packet segment. All the above procedures are solved by the traditional routed method. The SDN switch can conduct the packet handing and routing with different Granularity. For example, when a packet is routed to the same terminal with the specific destination IP address, it can have different routed methods in terms of the different destination TCP port.

2.2. The Previous Researches

As the references have many papers discussing the mobile management, the chapter mainly conduct the reference discussion whose mobile management mechanisms are similar to the SDN framework.

The reference [10] proposes the handover mechanism whose routing is updated in the local terminal with the use of the cross-layer so that the handover delay can be reduced. The method adopts the mobile device to notify the Switch for updating the handover. In this way, the mobile device needs to be modified so that the practicability is lower. The reference [15] proposes a rapid handover mechanism. The use of the handover of the Layer-2 or the Layer-3 should be decided by judging whether the handover of the mobile devices should change the subnet. The handover of the Layer-2 which avoids not changing the subnet should adopt to the handover procedure of the Layer-3, and the Layer-3 which agrees to change the subnet should adopt to the handover procedure of the Layer-2. At the same time, the Layer-2 (or the Layer-3) Trigger can be adopted to accelerate the handover procedure. The method also needs to modify the mobile devices, but its practicability is lower. The reference [12] proposes a Layer-3 Driving rapid handover whose handover request is detected and driven by the Layer-3. The decision and the driving function of the method should be in the mobile devices so that the mobile devices should also be modified and its practicability is also lower.

The reference [14] proposes a routing optimized method, whose original routed path should be through the Home Agent. After the route is optimized, the routed path can directly reach the destination terminal AP. The routing optimal method that makes the route after having handover, experience the updating of two stages. In this way, the required controlling information is much more. The difference between the framework and the SDN framework is that the controlling information of the SDN network is solved in the controllers and the routed packets are unnecessary to pass the centralized control units. After the routed packets can be sent to the Home Agent, the framework can optimize the subsequent routing. The reference [13] proposes the position update of the mobile device for finding out the method of the mobile device which is under the stand-by condition. In this way, AP can be divided into many Zones to maintain the rough position of the mobile devices. Although the concept of the Zone on the surface of the function can be adopted, the method is just fit to the mobile device which is under the stand-by condition.

3. THE METHODS OF THE MOBILE MANAGEMENT

In order to speed up the procedure of switching the AP, the paper adopts to the concept of the Zone and the pre-configured routed rules so that the up-link packets can be routed after the mobile devices switch the AP. The AP means the Neighbor APs of the Serving AP in the UE within the Zone. The routed rules should be pre-configured in the Neighbor APs so that the transmission of the up-link data packets can be conducted early.

In addition, the design of the on-line trigger is proposed. After the mobile devices are on-line, a new SDN Mobility Notify information should be proactively triggered to the SDN controller. In this way, the down-link routed routing can be updated. After the SDN receives the information, the target AP and the routed rules of the related switches should be adjusted. Later, the SDN controller just needs to adjust the AP and switches whose down-link routed rules are not prior configured. In this way, it is unnecessary to re-set the routed rules of each AP/Switch so that the re-setting time of the routed rules. The above design can reduce the delay of switching AP influenced by the SDN information and accelerate the procedure of switching the AP. The following two chapters will explain it in detail.

3.1. The Basic Procedures

The procedure of the mobile management method proposed in the paper shown in the Fig. (**4**) is as follows.

The SDN Controller initiates the Packet Flow routing rules of the UE. The Packet Flow Table Entry Format of the UE is established in a1 and s1. The Packet Flow routing rules should be pre-set in the neighbor AP (a2) and related Switch (s1).

1). The UE moves from a1 to a2.

2). a2 detects the adding of the UE.

3). a2 routes the up-link data packet in the UE.

4). a2 sends the Mobility Management Notify Information of the SDN to the SDN Controller.

5). The SDN Controller can use the priority to update the packet flow routing rules in the current routed paths of the UE. The Priority of the down-link packet flow routing rules in the S1 should be updated.

6). a2 begins to route the up-link and the down-link data packets in the UE.

7). The SDN Controller updates the pre-set packet flow routing rules in the UE, that is, the neighbor AP(a3) and its related Switch (s1 and s2) within the new Zone.

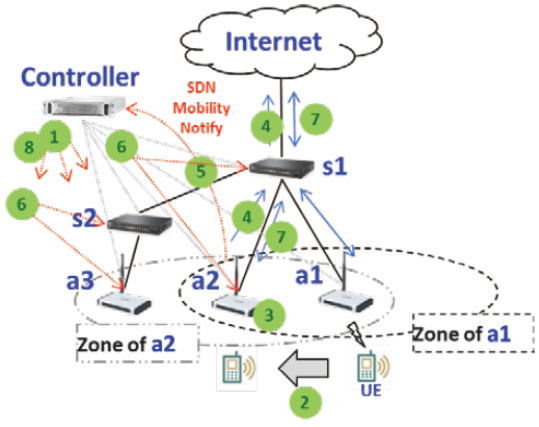

Fig. (4). The proposed flow picture of the mobility management.

The up-link and the down-link packet flow routing rules of the AP (a1, a2) within the Zone have been set before the second step (namely the handover). The Table **1** means the Flow Table of the related network equipment before the handover. The Switch s1 respectively sets two groups of the up-link and the down-link packet flow routing rules for it connects two or more AP within the Zone. The priority from the output to the a1 is higher, while the priority from the output to the a2 is lower. The two down-link packet routing rules are designed and their rules are the same, but their Priority is different. It can rapidly update the routing and reduce the packet delay after the handover.

Table 1. The packet flow routing rules of each network equipment (before the handover).

S1 data flow routing table				
In	Src.	Des.	Actions	Priority
p_Inet	*	UE_ip	Output:p_a1	0(高)
p_Inet	*	UE_ip	Output:p_a2	7(低)
p_a1	UE_ip	*	Output:p_s1	
p_a2	UE_ip	*	Output:p_s1	

aS1 data flow routing table			
In	Src.	Des.	Actions
p_wifi	UE_ip	*	Output:p_s1
p_s1	*	UE_ip	Output:wifi

a2 data flow routing table			
In	Src.	Des.	Actions
p_wifi	UE_ip	*	Output:p_s1
p_s1	*	UE_ip	Output:wifi

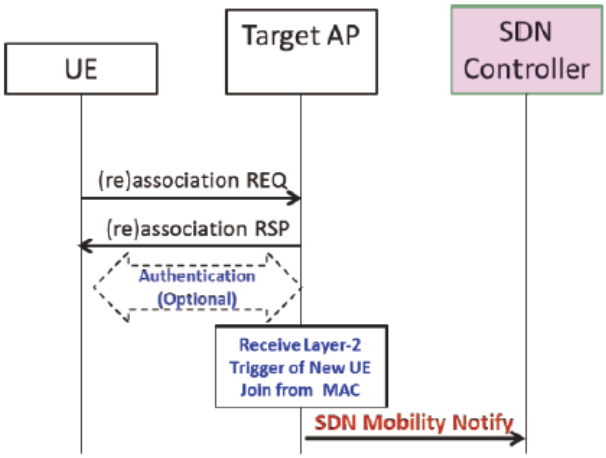

Fig. (5). The Information trigger process of the SDN Mobility Management Notify-the later trigger after the ending of the Layer-2 procedure.

The AP can send the SDN Mobility Management Notify information to the SDN Controller and its triggering methods have two kinds.

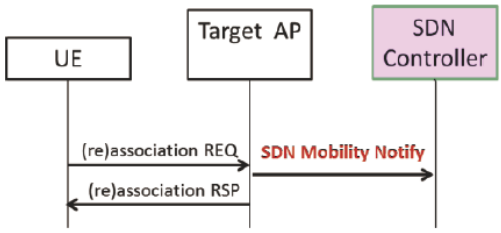

Fig. (6). The Information trigger process of the SDN Mobility Management Notify-the trigger after the information of the first Layer-2 is delivered to the AP.

The first method is that the AP can send the SDN Mobility Management Notify information to the SDN Controller after finishing the Layer-2 information switch, as shown in the Fig. (**5**). The advantages of the method is that its safety is higher for the authentication between the UE and the AP has been completed after finishing the Layer-2 information switch, but its handover delay will be longer. The second method is as shown in the Fig. (**6**). The AP receives the first Layer-2 information which is the same as sending the SDN Mobility Management Notify Information. The advantages of the method is that it can speed up the handover but its safety is lower.

Table 2. The prior updating packet flow routing rules in the network device after the handover.

S1 data flow routing table				
In	Src.	Des.	Actions	Priority
p_Inet	*	UE_ip	Output:p_a1	7(low)
p_Inet	*	UE_ip	Output:p_a2	0(high)
p_a1	UE_ip	*	Output:p_s1	
p_a2	UE_ip	*	Output:p_s1	

a2 data flow routing table			
In	Src.	Des.	Actions
p_wifi	UE_ip	*	Output:p_s1
p_s1	*	UE_ip	Output:wifi

The needed new path (the sixth step in the Fig. **4**) should be rebuilt after the handover when the SDN Controller receives the SDN Mobility Management Notify information, as shown in the Fig. (**7**). Therefore, the Flow Table along the network equipment should be prior set. Later, the route after the next handover should be set in advance (the eighth step in the Fig. **4**) for improving the efficiency of rebuilding the route after the next handover.

The packet flow routing rules in each network equipment after the handover are as shown in the Tables **2** and **3**. When the SDN Controller receives the SDN Mobility Management Notify information, the new route should be rebuilt. In order to complete the reconfiguration, it just needs to adjust the Flow Table of the S1 (as shown in the Table **2**) in the Fig. (**4**), that is, adjusting to the priority of the former two Flow Entry. In this way, the action of rebuilding the route can be reduced and the delay can also be shortened. The pre-set parts for the next handover include the following aspects, increasing the Flow Entry in the APa3 and the s2 in advance (as shown in the Table **2**).

Table 3. Pre-set the packet flow routing rules in the neighbor network devices after the handover.

a1 data flow routing table			
In	Src.	Des.	Actions
p_wifi	UE_ip	*	Output:p_s1
p_s1	*	UE_ip	Output:wifi

a2 data flow routing table			
In	Src.	Des.	Actions
p_wifi	UE_ip	*	Output:p_s2
p_s1	*	UE_ip	Output:wifi

S2 data flow routing table				
In	Src.	Des.	Actions	Priority
p_s1	*	UE_ip	Output:p_a3	
p_a3	UE_ip	*	Output:p_s1	

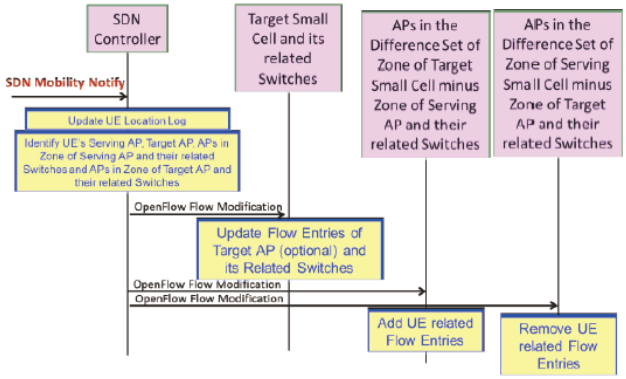

Fig. (7). The information processing procedure in the SDN Mobility Management Notify.

4. THE DIFFERENT COMPARISON OF THE HANDOVER DELAY

In order to understand the features of the proposed method, the comparison of the handover delay can be conducted between the two handover situations and the present SDN situation.

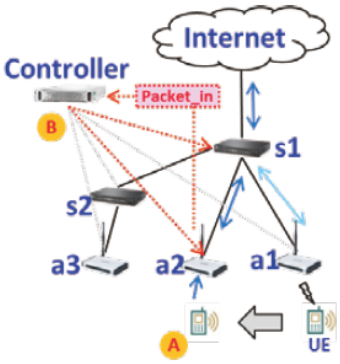

Fig. (8). The different comparison of the handover delay. Situation 1.

The situation refers to the Fig. (**4**) as shown in the Fig. (**8**) which belongs to the situation that the UE is handover from the AP a1 to the AP a2. Its analysis results of the handover delay difference are as shown in the Fig. (**9**). The general handover behavior in the SDN network is named as the traditional practice. The time by which UE sends the first data packet until the AP sends the Notify Information should be solved through the Flow Table after the AP receives the packet. The Packet information with the data packet is regarded as the judgment of the SDN Controller. The solving time in the AP is that the AP directly delivers the SDN Mobility Notify to the SDN Controller through the Layer-2 information after receiving the packet. Therefore, the time of finding whether there is the consistent Flow Entry within the Flow Table can be deleted. The period of time is the microsecond grade. Although there is a big difference between the traditional method and the proposed method, the difference of the consumed time is not significant. After the SDN Controller receives the Notify Information, the two Flow Entry in the AP a2 AP should be established and each Flow Entry in the S1 should be deleted and increased respectively within the traditional method, including the Flow Entry which is deleted to route the service AP and the Flow Entry which is increased to route the target AP. The proposed method in the paper just needs to update the Priority of the two Flow Entry in the S1, that is, completing the rebuilding of the main route. Generally speaking, the consuming time of updating the Flow Table is the microsecond grade and among the 4ms~100ms. Therefore, the number of establishing or updating the Flow Entry can be reduced so that the handover delay can also be reduced in the proposed Mobility Management method.

The Mobility management method proposed in the paper can reduce more unnecessary handover delay from the situation(2) (as shown in the Fig. **10**).The traditional method needs the increasing of the network equipment, including the AP a1, a3 and s2, while the proposed method just needs the Priority of the two Flow Entry in the s1. Compared with the traditional method, when the scale of the network becomes large, the more the number of establishing or updating the Flow Entry can be reduced, the more the difference of the handover delay will be.

CONCLUSION

This paper proposes a mobility management method under the SDN-based wireless networks, whose concepts of the zone and the pre-configured routing rules are utilized in the proposed method to enable the function of routing the up-link packets. In addition, an on-line trigger design is proposed to proactively trigger a SDN information to the SDN controller so that the down-link routed routing can be updated. After the SDN controller receives the information, each AP and the routed rules are just required to be adjusted without re-configuring the routed rules.

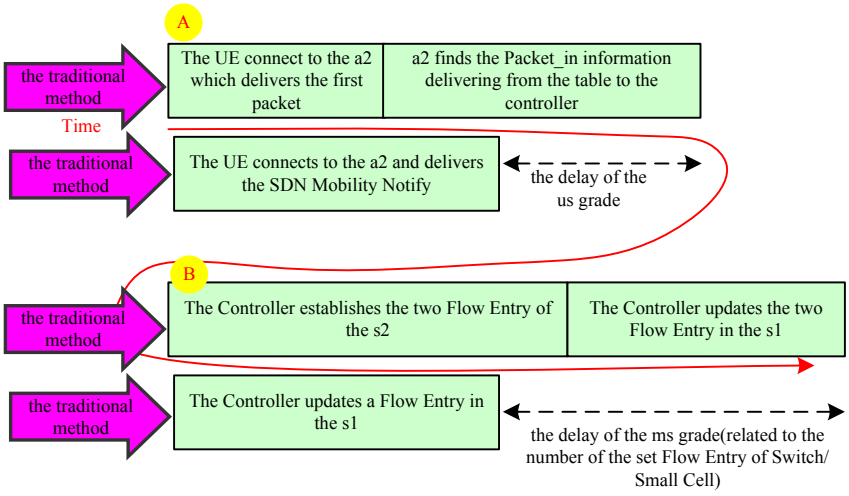

Fig. (9). The difference comparison of the handover delay. The difference comparison (1).

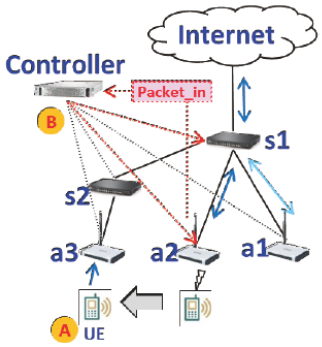

Fig. (10). The difference comparison of the handover delay. Situation (2).

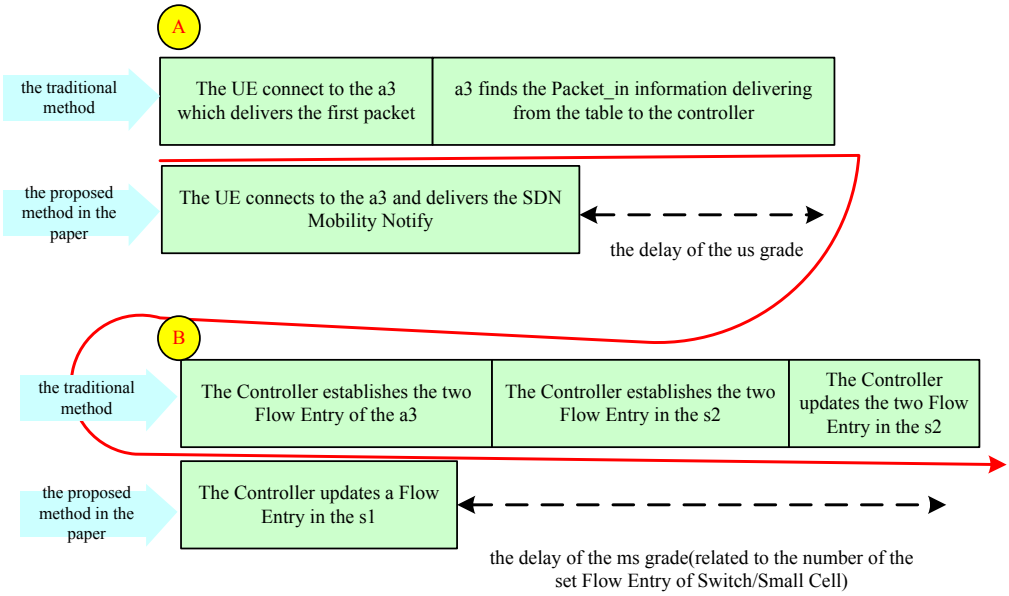

Fig. (11). The difference comparison of the handover delay. The difference comparison (2).

Compared with the traditional SDN network, the proposed method can reduce much time by updating the Flow Table. In general, the consuming time of updating the Flow Table is the microsecond grade. When the scale of the network becomes large, the more the number of establishing or updating the Flow Entry can be reduced, the more the difference of the handover delay will be.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

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