

Media Independent Service for Software-Defined Radio Access Networks

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Abstract—In recent days, Software-defined networking paradigm, characterized by a clear separation of the control and data planes, has been attracted in wireless Radio Access Networks (RANs). This paper proposes and presents an approach for applying IEEE 802.21 Media Independent Services (MIS) framework to the Software-Defined Radio Access Network (SDRAN). MIS-capable centralized controller in this approach enables both seamless handover and dynamic radio resource allocation by keeping a clear separation of MIS control from SDN control plane in heterogeneous RAN environment.

Keywords—Software-defined radio access network, SDRAN, IEEE 802.21, MIS, Media independent service, Seamless Handover, Heterogeneous Network

I. INTRODUCTION

A Radio Access Network (RAN) is part of a mobile network that is implemented with a radio access technology. Conceptually, it resides between mobile devices such as a mobile phone and provides connection with its Core Network (CN). RANs differ from CNs in that they mostly deal with L1/L2 functions, such as interference, cell ID, neighbour lists, and handover threshold.

In recent days, Software-Defined Networking (SDN) paradigm has been attracted in wireless RANs. The SDN approach, characterized by a clear separation of the control and data planes, allows that operators can do quicker provisioning and configuration of network connections without requiring independently accessing and configuring each of the network's hardware devices. Software-Defined Radio Access Network (SDRAN) is the RAN including fronthaul and backhaul, which adopts the SDN concept and architecture [1].

In this paper, we propose an approach for applying IEEE 802.21 Media Independent Services

(MIS) framework to the SDRAN. MIS framework of IEEE 802.21-2008 standard has been a common platform to support mobility management in heterogeneous RAN networks [2~4]. MIS framework can support seamless handover by using Media Independent Event Service (MIES), Media Independent Command Service (MICS), and Media Independent Information Service (MIIS). MIES primitives and messages help Mobile Node (MN) to monitor link status (e.g., signal strength and data rate), and MICS primitives and messages help MN to control its link layers (physical layer and data link layer) for seamless handover in heterogeneous networks. The objective of MIIS is to gain knowledge about all heterogeneous networks in the area of interest of the terminal to facilitate handovers when roaming across these networks.

It is possible to expect that MIS Framework enables MN to monitor link, allocate resource, and enables seamless handover of MNs in SDRANs [5~7]. The SDRAN can be characterized by a clear separation of the MIS control plane and SDN control plane. The SDRAN is the simplest solution for future wireless RANs where various applications connected through SDN networks conserve their independence.

This paper presents the application of IEEE 802.21 MIS framework to SDRAN for seamless handover and radio resource management. The remainders of the paper are organized as follows. In section II, we explain the MIS framework architecture for SDRANs. Section III describes service scenarios and signal flows for seamless handover based on IEEE 802.21 MIS framework in

information server at the core network sends handover policies to the PoA Controller and receives context information of each PoA controller and its attached users.

A. Media Independent Service Reference Model

A network reference model including MIS services is shown in Fig. 2 to illustrate the MIS reference points for SDRAN. The model includes an MIS-capable MN that supports multiple wired and wireless access technologies. An MN exchanges MIS information with its MIS point of service (PoS) within the PoA Controller. The MISF in any Network Entity becomes an MIS PoS when it communicates directly with an MN-based MISF. When an MISF in a PoA does not have a direct connection to the MN, it does not act as an MIS PoA for that particular MN.

The MN can use L2 transport for exchange MIS information with an MIS PoS that resides in its PoA Controller. The MN can also use L3 transport for exchanging MIS information with an MIS PoS that resides in its PoA Controller. This framework supports use of both L2 and L3 mechanisms for communication among MIS network entities.

Figure 2 also shows the MISF communication model. The model shows MISFs in different roles and the communication relationships among them. This model assumes that the serving network either operates multiple link-layer technologies or allows its user to roam into other networks when a service level agreement (SLA) in support of inter-working has been established.

The communication model identifies the reference points between different instances of MISF.

- Reference point RP1 refers to MISF procedures between the MISF on the MN and the MIS PoS on the Network Entity of its serving PoA.
- Reference point RP2 refers to MISF procedures between the MISF on the MN and the MIS PoS on the Network Entity of a candidate PoA.
- Reference point RP3 refers to MISF procedures between the MISF on the MN and the MIS PoS on the PoA Controller.

- Reference point RP4 refers to MISF procedures between an MIS PoS in a Network Entity and an MIS PoS instance in PoA Controller.
- Reference point RP5 refers to MISF procedures between an MIS PoS in a Network Entity and an MIS PoS instance in different Network Entities.

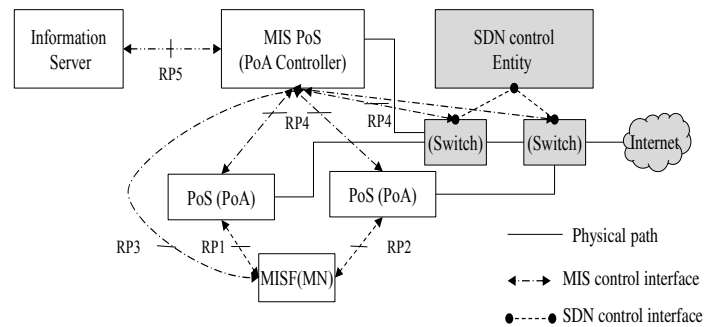


Figure 2. MIS reference model for SDRAN

B. MISF Service Access Points (SAPs)

Figure 3 shows MISF in a protocol stack and the interaction of the MISF with other elements for handover control. All exchanges between the MISF and other functional entities occur through service primitives grouped in SAPs. Each SAP consists of a set of service primitives that specify the interaction between the service user and provider.

The specification of the MISF includes the definition of SAPs that are media independent and recommendations to define or extend other SAPs that are media dependent. Media independent SAPs allow the MISF to provide services to the upper layers of the mobility-management protocol stack, the network management plane, and the data bearer plane. The MIS_SAP and associated primitives provide the interface from MISF to the upper layers of the mobility-management protocol stack. Upper layers need to subscribe with the MISF as users to receive MISF generated events and also for link-layer events that originate at layers below the MISF but are passed on to MIS users through the MISF. MIS users directly send commands to the local MISF using the service primitives of the MIS_SAP. Communication between two MISFs relies on MIS protocol messages.

PoAs and their resource availability. Such information includes whether candidate networks and MN support radio resource management or not, and the availability of MIS service on the SDN Controller. The handover preparation consists of all steps of link measurements, collection of information about neighboring PoAs, and exchange of information about resource availabilities by these PoAs.

3. In the third stage, handover decision is the procedure to decide whether the connection to be switched to a new PoA based on parameters collected in the handover preparation phase. The evaluation can be made by the MN or the network based on parameters such as signal strength, target QoS, cost, resource availability, and operator policy. After then, radio resource allocation has been prepared by PoA Controller or via SDN Controller based on PoA's link status or radio resource allocation of neighboring PoAs.
4. In the last stage, PoA's radio resources (e.g., frequency, time, interface mode and power) are configured by PoA or PoA Controller. MN prepares to connect to RAN with newly allocated radio resources as an action of Handover execution. After then, PoA reports its allocated radio resources to Information Server, PoA Controller (or SDN controller), and neighboring PoAs.

B. Signal Flows

Over the SDRANs, handover triggers generated by the link layer are exploited by the MISF incorporated in the PoA Controller to make easy vertical handover. This procedure has the four phases described in previous Session (Handover Initiation, Handover preparation, Handover decision and Handover execution). The solid lines in Fig. 4 to Fig. 7 show the MIS signal flows of the MIS protocol.

1) Stage 1: Handover Initiation

The handover initiation phase is start when the Mobile Node is connected to the serving network via the current PoA (PoS 1). The Mobile Node queries information about neighboring networks by

sending an MIS_Get_Information request message (see b in Figure 4) to the Information Server. The Information Server responds with an MIS_Get_Information response message (see c in Figure 4). This information is attempted as soon as the Mobile Node is first attached to the PoS 1 and it has access to the MIS Information Server. Figure 4 shows an example signal flow for handover initiation.

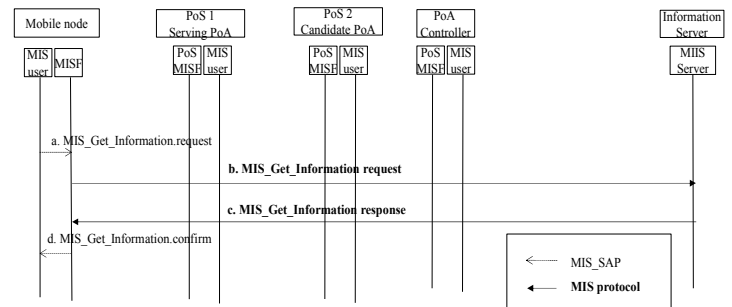


Figure 4. Signal flows for handover initiation procedure

2) Stage 2: Handover Preparation

Figure 5 shows an example signal flow for handover preparation. When detecting a new link, the Mobile Node triggers a mobile-initiated handover by sending an MIS_MN_HO_Candidate_Query request message to the PoA Controller (see d in Figure 5). This request contains the information of potential candidate networks. The PoA Controller extracts context information of both attached users and neighboring RANs. The PoA Controller queries the availability of resources at the candidate PoAs by sending an MIS_N2N_HO_Query_Resources request message to one or multiple Candidate PoAs (see g in Figure 5). The Candidate PoAs respond with an MIS_N2N_HO_Query_Resources response message (see j in Figure 5) and the PoA Controller notifies the Mobile Node of the resulting resource availability at the candidate PoAs through an MIS_MN_HO_Candidate_Query response message (see m in Figure 5). Thus, the MN has enough information about the neighbouring networks to make a handover decision based on policies and multi-criteria of decision in either MN or network centric approach.

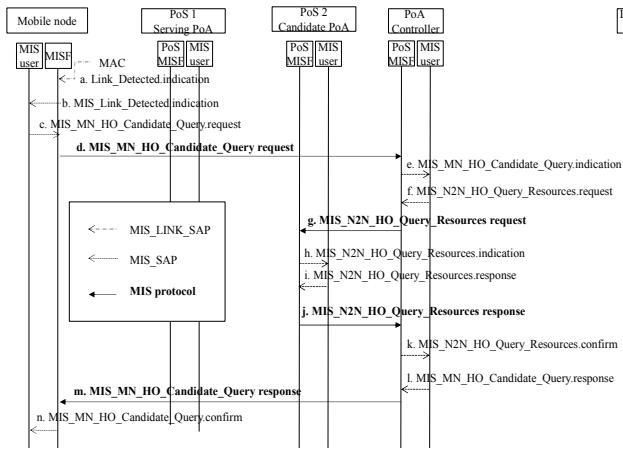


Figure 5. Signal flows for handover preparation procedure

3) Stage 3: Handover Decision

After executing the selection mechanism and determining the preferred candidate target RAN, the Mobile Node decides on the target of the handover, and notifies the PoA Controller of the decided target network information by sending the MIS_MN_HO_Commit request message (see b in Figure 6). The MIS_MN_HO_Commit request message includes information on MN's newly allocated radio resources (e.g., frequency band and transmit power). The PoA Controller sends the MIS_N2N_HO_Commit request message (see e in Figure 6) to the Target PoA (PoS 2) to request resource preparation at the target network. The Target PoA (PoS 2) responds with the result of the resource preparation by an MIS_N2N_HO_Commit response message (see h in Figure 6). The target PoA (PoS 2) can reply to the PoA Controller (MIS PoS) by sending MIS_N2N_HO_Commit response message (see h in Figure 6) to prepare connection with newly allocated resources. The PoA Controller (MIS PoS) can respond to PoA (PoS 1) by sending MIS_MN_HO_Commit response message (see k in Figure 6) to prepare connection with newly allocated resources and PoA 1 itself can allocate its radio resources.

4) Stage 4: Handover Execution

When the MN moves its attachment from a previous PoA (PoS 1) to a new PoA (PoS 2), certain handover execution procedure is carried out between the Mobile Node and the PoA Controller as follows: After radio link has been activated, the Mobile Node establishes the new layer 2 connection

and sends an MIS_MN_HO_Complete request message to the PoA Controller (see d in Figure 7).

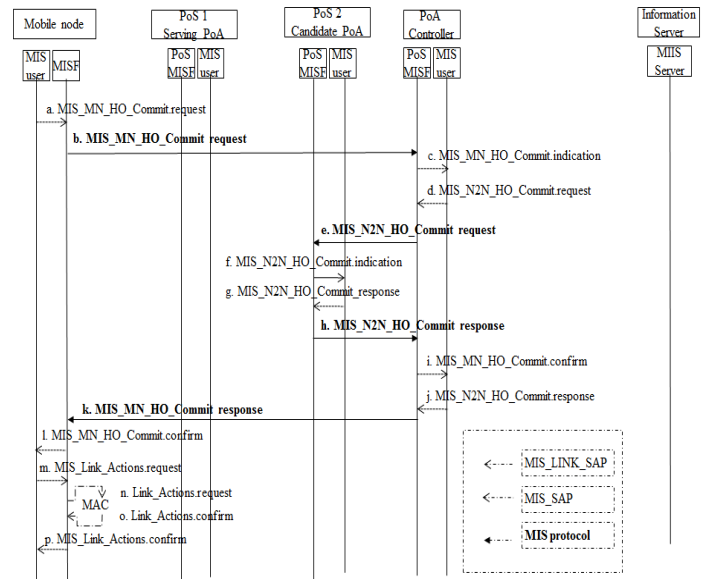


Figure 6. Signal flows for handover decision procedure

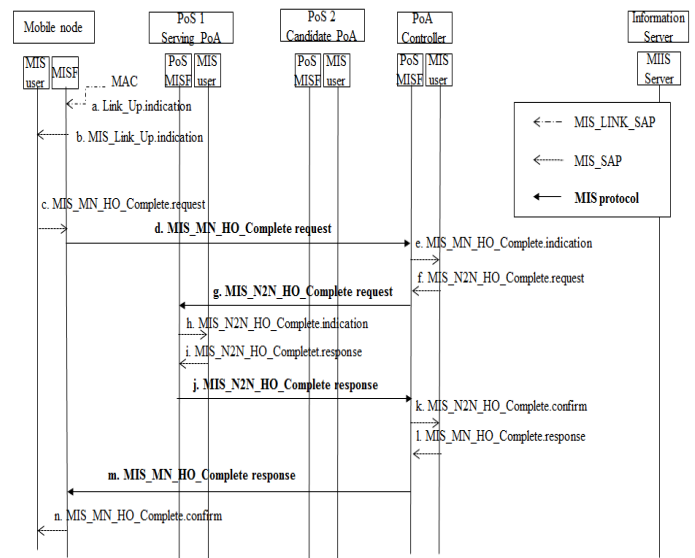


Figure 7. Signal flows for handover execution procedure

After finishing handover, the PoA Controller sends an MIS_N2N_HO_Complete request message to the previous Serving PoA (PoS 1) to release resource (see g in Figure 7), which was allocated to the Mobile Node. After identifying that the resource is successfully released upon receiving (j) MIS_N2N_HO_Complete response message, the PoA Controller sends an (m) MIS_MN_HO_Complete response message to the

Mobile Node. The handover procedure is completed when MN receives the (m) MIS_MN_HO_Complete response message from PoA controller.

IV. CONCLUSIONS

This paper proposed and presented an approach for applying IEEE 802.21 MIS framework to the SDRAN. In this decoupled approach, MIS-capable centralized controller enables both seamless handover and dynamic radio resource allocation by keeping a clear separation of MIS control from SDN control plane in heterogeneous RAN environment.

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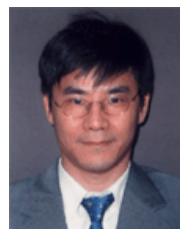
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