Radio Resource Management Based on IEEE 802.21 Media Independent Service Framework

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Abstract— **As various radio access technologies and multi-mode terminals incorporating multiple network interfaces have appeared, interferences between wireless access networks have increased. This paper proposes radio resource management in heterogeneous radio access networks based on IEEE 802.21 Media Independent Service (MIS) Framework. The proposed schemes use MIS framework of IEEE 802.21 standard as a common platform to support radio resource management in heterogeneous networks.**

Keywords—**IEEE 802.21, MIS, radio resource management, Interworking, Heterogeneous network, MIH, WLAN**

I. INTRODUCTION

In recent days, networks with various communication technologies have appeared, and thus interferences between wireless access networks have increased. For example, 2.4GHz band is used by WLAN devices and WPAN devices such as Bluetooth devices, and 5GHz band is used by WLAN devices and cordless phones. Moreover, 5GHz band is considered for use of long term evolution (LTE) technology, and therefore interference in 5GHz band is expected to increase. To reduce the interferences and increase the spectrum usage, radio resource management in heterogeneous networks is needed.

IEEE 802.21 working group (WG) published a standard on media independent handover (MIH) technology, which provides seamless handover in heterogeneous networks [1]. Afterwards, its task groups such as task groups a, b, c, and d have standardized technologies to solve additional issues on handover in heterogeneous networks [2-9]. In recent days, the IEEE 802.21 WG has been studying various use cases for heterogeneous network interworking such as network-assisted D2D communication, radio resource management, and interworking model between IEEE 802.21 and software-defined networking. IEEE 802.21 task groups m (TGm) and 1 (TG1) are doing respectively standardization works on the framework and use cases of media independent service (MIS) that include not only seamless handover but also various interworking issues in heterogeneous networks [10].

The MIS framework of IEEE 802.21 standard can be a common platform to support resource management in heterogeneous networks. MIS framework of IEEE 802.21 standard supports seamless handover in heterogeneous networks by using primitives and messages of event service, command service, and information service. Primitives and messages of event service help mobile node (MN) to monitor link status (e.g., signal strength and data rate), and primitives and messages of command service help MN to control its link layers (physical layer and data link layer) for seamless handover in heterogeneous networks. It is possible to expect that MIS framework enables MN to monitor link status and control radio resources (e.g., frequency, time, and power) for radio resource management. Primitives and messages of information service are used to transfer network configuration information for handover in heterogeneous networks, and thus they can be used to provide network configuration for radio resource allocations in heterogeneous networks. Thus, MIS framework is appropriate for resource management in heterogeneous networks that use various communication technologies and various frequency bands [11].

This paper proposes radio resource management in heterogeneous radio access networks based on IEEE 802.21 MIS framework. The remainders of the paper are organized as follows. In section II, we explain media independent services framework of IEEE 802.21. Section III describes radio resource management schemes based on IEEE 802.21 MIS framework. In section IV, we offer concluding remarks.

II. MEDIA INDEPENDENT SERVICES FRAMEWORK

IEEE 802.21-2008 standard defines a MN as the mobile terminal that can perform handover between heterogeneous networks, a point of attachment (PoA) as the network entity (e.g., base station in cellular networks and access point in WLAN) that establishes link layer connection with MN, and an MIS point of service (PoS) as the network entity that supports MIS function (MISF) [1]. IEEE 802.21-2008 standard describes mobile-initiated handover triggered by an MN as well as network-initiated handover triggered by MIS PoS.

The MIS technology can provide interaction between MIS user (network layer or higher layer than the network layer) and link layer (physical layer and data link layer), and thus reduce handover latency. The interactions are defined as MISs that consist of media independent event service (MIES), media independent command service (MICS), and media independent information service (MIIS). MIES is used for link layer to report link status (e.g., signal strength and data rate) to MIS user; MICS is used for link layer control (e.g., network discovery and network connection); MIIS is used to provide network configuration information (e.g., location information and network connection information) to mobile terminal. MISF is a functional entity that realizes MISs in mobile terminals and network entities. MIS PoS is network entity that is equipped with MISF and controls network connection of mobile terminals. Information Server is a data base system that manages network configuration information.

MISF in Fig. 1 is a functional entity that realizes MISs in mobile terminals and network entities. MISF of a mobile terminal or a network entity can interact with MIS user, Link layer, and remote MISF that does not belong to the same mobile terminal or same network entity. For these kinds of interactions, MISF has interfaces called service access points (SAPs). MIS_SAP, MIS_LINK_SAP, and MIS_NET_SAP in Fig. 1 are SAPs to be used for interacting with MIH user, link layer, and remote MISF. Interaction signals through MIS_SAP or MIS_LINK_SAP are defined as MIS primitives, and interaction signals through MIS_NET_SAP are defined as MIS messages.

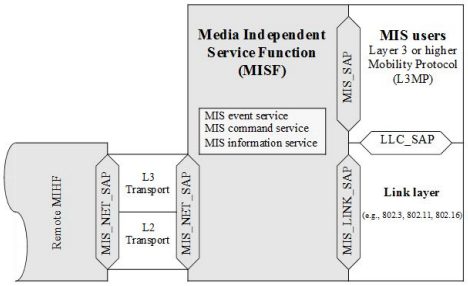

Figure 1. General MISF reference model and SAPs [1]

Figure 2 shows the MISF communication model. The model shows MISFs in different roles and the communication relationships among them. The communication relationship shown in Fig. 2 applies only to MISFs.

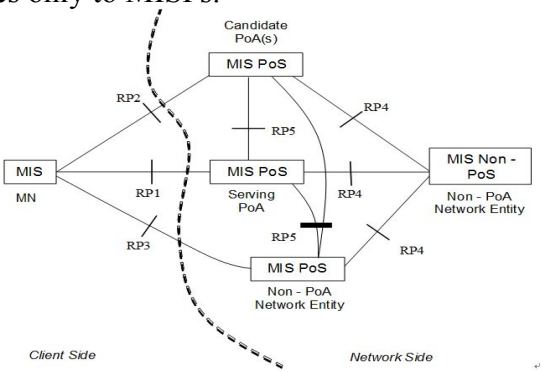

Figure 2. MISF communication model [1]

III. RADIO RESOURCE MANAGEMENT BASED ON IEEE 802.21 MIS FRAMEWORK

A. High level illustration

Figure 3 shows media independent service framework for resource management in heterogeneous networks. PoA Controller (i.e., access point (AP) controller) can control resources of PoS(PoA)s that use various communication technologies (e.g., WLAN, Wi-Fi Direct, Bluetooth, and LTE) by using MICS

message. PoS(PoA)s can use different communication technologies and share its link status by using MIES message. PoA Controller can be implemented as MIS PoS.

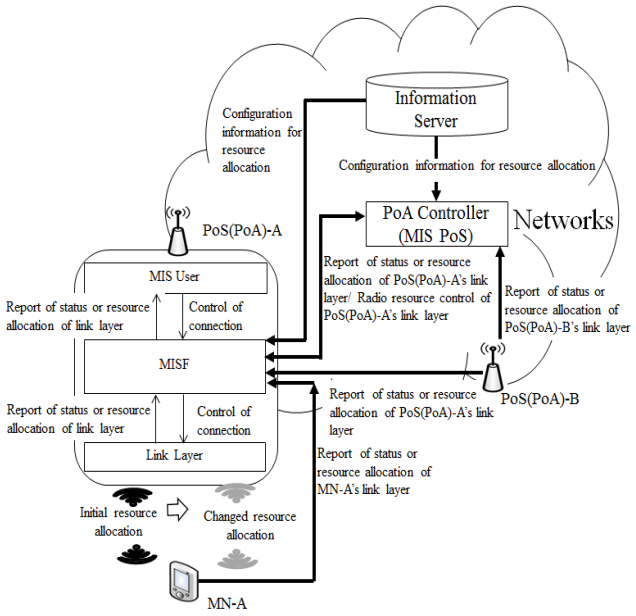

Figure 3. Media independent service framework for resource management in heterogeneous networks

The following entities are equipped with MISF.

a. MN-A: a user device, such as a smart phone, which are equipped with radio interfaces of multiple radio access technologies
b. PoS(PoA)-A: a PoS with PoA, such as base station (BS) in cellular networks or AP in WLAN, which is a network entity that establishes link connection with the MN
c. PoS(PoA)-B: PoS(PoA)-A's neighboring PoS(PoA) that can interfere with MN or PoS(PoA)-A
d. PoA Controller: a network entity that can manage radio resources of PoS(PoA)-A
e. Information Server: a server that manages configuration information on PoS(PoA)s' radio resource allocation

B. Stages for radio resource allocations

Radio resource allocation of radio access network comprises four stages as following.

1. In the first stage, PoS(PoA)'s radio resource allocation is decided by PoS(PoA) itself or PoA Controller based on PoA's link status, link status or radio resource allocation of neighboring PoS(PoA)s, or configuration information from Information Server.
2. In the second stage, MN prepares to connect to radio access network with newly allocated radio resources.
3. In the third stage, PoS(PoA)'s radio resources (e.g., frequency, time, and power) are allocated by PoS(PoA) itself or PoA Controller.
4. In the last stage, PoS(PoA) reports its allocated radio resources to Information Server, PoA Controller, and neighboring PoS(PoA)s.

C. Stage 1: decision of PoS(PoA)'s radio resource allocation

PoS(PoA) itself can decide allocation of its own radio resources. Otherwise, PoA Controller can decide radio resource allocations for PoS(PoA) on behalf of PoS(PoA). Link_Resource_Report and MIS_Resource_Report primitives/messages are proposed for this stage as new primitives and messages.

1) Decision by PoS(PoA)

PoS(PoA) can decide its radio resources based on its link status. Link_Parameter_Report and MIS_Link_Parameter_Report primitives/messages in IEEE 802.21 standard can be used for this case.

PoS(PoA) can decide its radio resource allocation based on link status of MN. MN may experience bad link status due to some reasons (e.g., radio interference). In this case, if MN (e.g., MN-A) reports its link status to PoS(PoA) (e.g., Pos(PoA)-A) by using Link_Parameter_Report and MIS_Link_Parameter_Report primitives/messages in IEEE 802.21 standard, PoS(PoA) can allocate appropriate radio resources for MN.

PoS(PoA) can decide its radio resource allocations based on reports from neighbouring PoS(PoA). If PoS(PoA) (e.g., Pos(PoA)-A) and its neighbouring PoS(PoA) (e.g., PoS(PoA)-B) use the same radio resources, they interfere with each

other and need to reallocate their radio resources for improving their link status. In this case, PoS(PoA)-B can report its link status and radio resource allocation information to PoS(PoA)-A. To report information on PoS(PoA)-B's allocated radio resources (e.g., frequency bands and transmit power), Link_Resource_Report and MIS_ Resource_Report are used, which are proposed as new primitives/messages. Link_Parameters_Report and MIS_Link_Parameters_Report primitives/messages in IEEE 802.21 standard are used to report PoS(PoA)-B's link status.

PoS(PoA) can query configuration information to Information Server, and then allocate its own radio resources based on the configuration information. PoS(PoA) can request configuration information such as network type (e.g., IEEE 802.11 and CDMA), frequency bands, and location information of neighboring PoS(PoA)s to Information Server. Based on configuration information from Information Server, PoS(PoA) can allocate its own radio resources. To query configuration information, MIS_Get_Information primitives/messages that are primitives/messages in IEEE 802.21-2008 standard can be used.

2) Decision by PoA Controller

PoA Controller also can decide radio resource allocation for PoS(PoA) based on reports about link status or radio resource allocation of PoS(PoA)s controlled by PoA Controller. The PoS(PoA)-B is PoS(PoA) controlled by PoA Controller. PoS(PoA)-B can report its link status and radio resource allocation to PoA Controller, and then PoA Controller can allocate radio resources for PoS(PoA)-A. Proposed new primitives/messages, Link_Resource_Report and MIS_Resource_Report, are used to report information on PoS(PoA)-B's allocated radio resources (e.g., frequency bands and transmit power). To report PoS(PoA)-B's link status, Link_Parameters_Report and MIS_Link_Parameters_Report primitives/messages in IEEE 802.21 standard are used.

PoA Controller can query configuration information to Information Server, and then allocate radio resources for PoS(PoA). PoA Controller can request configuration information such as network type, frequency bands, and location information of PoS(PoA)s controlled by PoA Controller to Information Server. Based on configuration information from Information Server, PoA Controller can allocate appropriate radio resources of PoS(PoA). To query configuration information, MIS_Get_Information primitives/messages that are primitives/messages in IEEE 802.21-2008 standard can be used.

D. Stage 2: preparation of MN's connection with newly allocated radio resources

Before PoS(PoA) allocates new radio resources, MN needs to prepare changing its connection with newly allocated radio resources of PoS(PoA) that MN connects to. Before performing radio resource allocation, MN can receive from PoA Controller or PoS(PoA) the information on new radio resources that MN connects to. MIS_Link_Preparation primitives/messages are proposed for this stage as new primitives and messages.

1) Request for preparation of MN's connection from PoS(PoA)

PoS(PoA) requests MN to prepare connection with newly allocated radio resources by using MIS_Link_Preparation primitives/messages that are newly proposed. The primitives and messages of MIS_Link_Preparation include information on PoS(PoA)'s newly allocated radio resources (e.g., frequency band and transmit power). The MN-A connects to PoS(PoA)-A, and thus MN-A can be requested to prepare connection with new radio resources by PoS(PoA)-A.

2) Request for preparation of MN's connection from PoA Controller

PoA Controller also can request MN to prepare connection with newly allocated resources by using MIS_Link_Preparation primitives/messages that are newly proposed, as shown in Fig. 4.

E. Stage 3: Allocation of PoS(PoA)'s Radio Resources

In this stage, PoS(PoA)'s radio resources are allocated by PoS(PoA) or PoA Controller. For this stage, MIS_Resource_Allocation and Link_Resource_Allocation primitives/messages

are newly proposed for allocating radio resources of PoS(PoA).

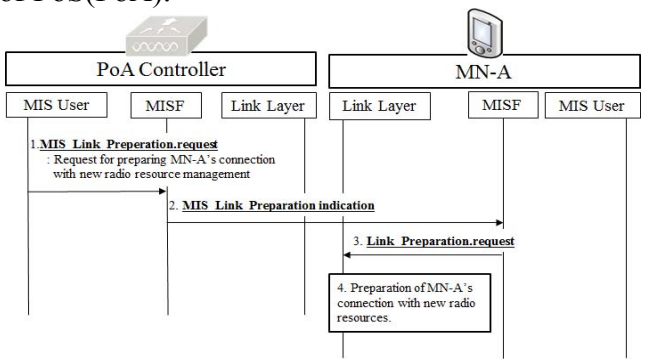

Figure 4. PoA Controller requests MN-A to prepare connection with newly allocated radio resources

1) PoS(PoA)'s radio resource allocation by PoS(PoA)

PoS(PoA) itself can allocate its radio resources, as shown in Fig. 5. MIS_Resource_Allocation.request and Link_Resource_Allocation.request primitives are new primitives for allocating radio resources and include parameters that represent radio resources (e.g., frequency band, transmit power, and time slot). Link_Resource_Allocation.confirm and MIS_Resource_Allocation.confirm should include a parameter to present result (e.g., success or fail) of radio resource allocation.

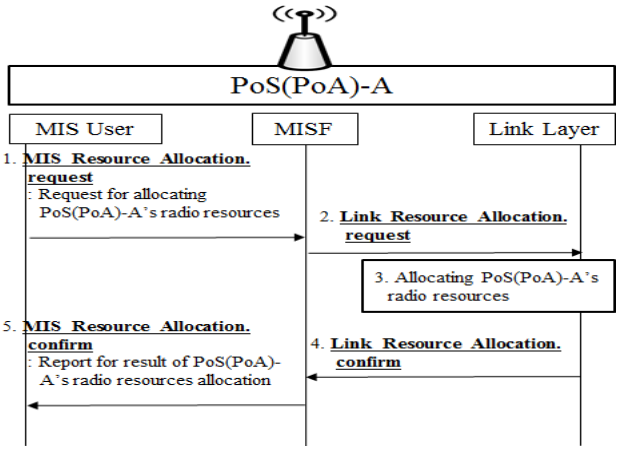

Figure 5. PoS(PoA) allocates its own radio resources

2) PoS(PoA)'s radio resource allocation by PoA Controller

MIS user of PoA Controller can request PoS(PoA)'s link layer to allocate radio resources as shown in Fig. 6. Proposed new primitives, MIS_Resource_Allocation.request and Link_Resource_Allocation.request are used for PoS(PoA) Controller to allocate radio resources of PoS(PoA).

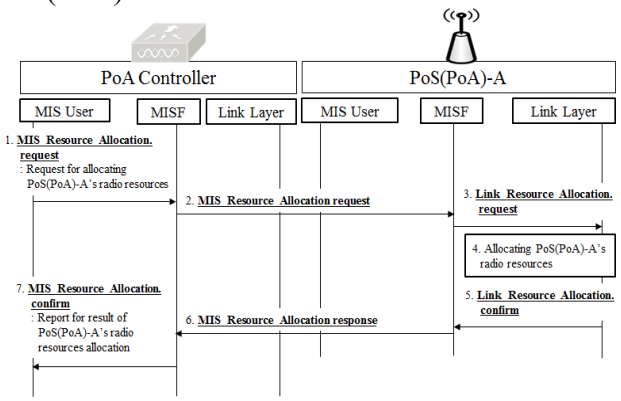

Figure 6. PoA Controller allocates radio resources for PoS(PoA)

F. Stage 4: Report of PoS(PoA)'s allocated radio resources

After radio resource allocation of PoS(PoA), PoS(PoA) should report its updated radio resources to other network entities such as neighboring PoS(PoA), PoA Controller, and Information Server, as shown in Fig. 7. Proposed new primitives/messages, MIS_Resource_Report and Link_Resource_Report are used for reporting PoS(PoA)'s updated radio resource allocation. They include parameters that represent updated radio resources of PoS(PoA).

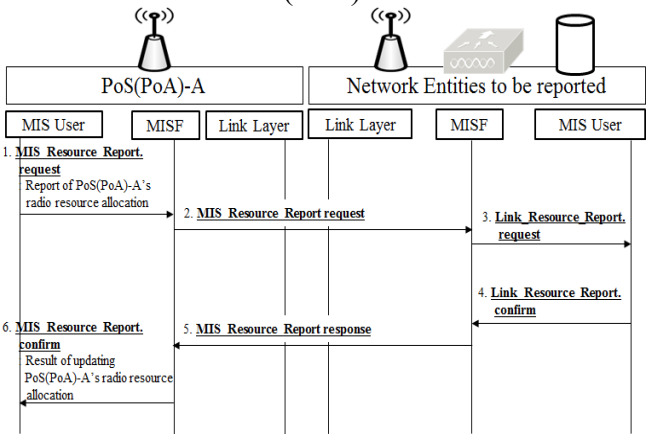

Figure 7. PoS(PoA) reports its radio resources to other its updated radio resources to other network entities

IV. CONCLUSIONS

This paper proposed radio resource management in heterogeneous radio access networks based on IEEE 802.21 MIS framework. The proposed schemes use MIS framework of IEEE 802.21 standard as a common platform to

support radio resource management in heterogeneous networks. Future technology of heterogeneous network interworking will be integrated mobility and resource managements of heterogeneous networks for improving users' satisfaction. We expect that our proposed radio resource management schemes will be utilized for the integrated mobility and resource managements of heterogeneous networks.

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