Service Procedures for On-board UEs in the 3GPP Mobile IAB Systems

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***Abstract*— This paper proposes a method for providing services to users aboard an UAM (Urban Air Mobility) equipped with mobile IAB (Integrated Access and Backhaul). The IAB has been standardized for the fixed relay in the 3GPP. For the mobile relay, the mobile IAB is currently being discussed to extend the IAB functionality. However, the mobile IAB has been considered only for vehicle environments. Recently, UAM has been considering as one of the most important services for 6G communications. Thus, this paper considers a new scenario that users board a UAM equipped with a mobile IAB system. Since it is difficult for the UAM to determine whether the user is in the UAM or not, it is essential to consider several procedures for the service continuity between the terrestrial and the non-terrestrial communication systems.**

Keywords—5G, 6G, UAM, and Mobile IAB

I. INTRODUCTION

3GPP standardization groups have discussed the IAB network structure that can provide wireless backhaul links and access links based on multi-hop relay since Rel-16 in 2017. They have discussed IAB procedures that apply a plug-and-play method to provide autonomous backhaul link and procedures for providing mobility of IAB. Currently, they are also considering a scenario in which a mobile IAB is mounted on a vehicle to provide a service. Mobile IAB, a mobile relay technology in 3GPP, is in progress to improve mobility in IAB.

For the 6G mobile communications, several requirements or scenarios that can provide various services to users not only on the ground but also in three-dimensional space are reviewed. A scenario in which a user boards a UAM moving in a three-dimensional (3D) space and receives a service is considered. It has been also considered to install Mobile IAB on UAMs to provide services to users aboard UAMs for the 6G mobile communications. It may be difficult to exploit the existing procedures to provide the service continuity between the terrestrial and the non-terrestrial communication systems when users board to a UAM equipped with a Mobile IAB. This is because there is an ambiguous point to determine whether the user is in the UAM or not. The frequency band for the UAM may be different from the terrestrial mobile communication systems. Therefore, we consider several service scenarios for the on-board users in the UAM and propose new procedures for the service continuity.

II. RELATED WORK

IAB enables wireless relaying in NG-RAN (NG Radio Access Network). The relaying node, referred to as *IAB-node*, supports access and backhauling via NR (New Radio). The terminating node of NR backhauling on network side is referred to as the IAB-donor, which represents a gNB with additional functionality to support IAB. Backhauling can occur via a single or via multiple hops. The IAB architecture is shown in Figure 1[1].

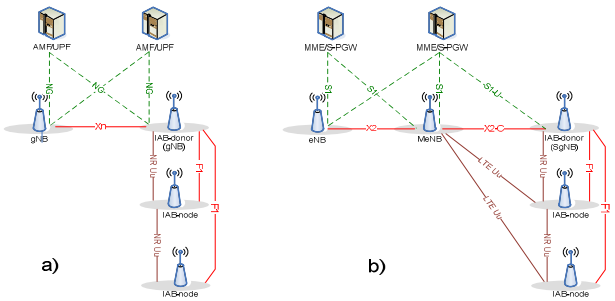

Fig.1.IAB architecture; a) IAB-node using SA mode with NGC; b) IAB-node using EN-DC

In 3GPP, Mobile IAB items have been in progress in RAN in Rel-18 since September 2022. Mobile IAB is based on the Rel-17 IAB structure and protocol, and the IAB-node is mounted on the mobile vehicle and provides 5G communication services to terminals adjacent to the inside and outside of the vehicle of the IAB-node. Mobile IAB is defined as an IAB-node that only services user terminals without Child IAB-node. The movement of the IAB-node is a concept in which the cell moves, resulting in new problems to be solved. In order to strengthen the frequent mobility support of Mobile IAB-node, optimization of topology adaptation procedures, improvement of group handover technology of user terminals connected to Mobile IAB-node, and interference with surrounding cells (e.g., PCI collision, etc.) are discussed in detail.

In addition, SA defines the Mobile IAB node as MBSR (Mobile Base Station Relay) in terms of wireless access networks, and is proceeding in terms of 5G system requirements and structure for vehicle-mounted relays. SA1 discussed the Use Case and Requirements for MBSR and reflected it in 5G System Stage 1 specification TS 22.261 in September 2021. In SA2, issues and solutions such as mobility

and access management of terminals connected to MBSR, cell ID and TAC (Tracking Area Code) management of MBSR, and location service provision to terminals connected to MBSR were written as TR 23.700-05 in December 2022. Based on this, SA is working to reflect MBSR as a standard in 5G System architecture Stage 2 specification TS 23.501.

III. Proposed Method

This section describes the procedure for providing services to users in consideration of the scenario in which the user rides on a bus or UAM equipped with a mobile IAB node. This paper proposes the structure of the mobile IAB system as shown in Figure 2. A procedure for a user to board a bus or UAM and receive a service will be described as follows. Figure 3 describes the procedure for registration of the mobile IAB service and service continuity.

1. Start the registration process before the terminal boards the mobile IAB. For example, before riding a bus or train, choose to tag a terminal installed on a mobile object or to start a service through a mobile IAB through an app installed on the user's terminal. As an example, for starting a mobile IAB service registration procedure in the network, a registration request message is transmitted. A mobile IAB service is defined as a mobile IAB service in which a terminal receives a data service through a mobile IAB installed on a mobile vehicle or a bus. In order to deliver the contents for mobile IAB service registration to the network in an application that manages mobile IAB services, the contents are delivered using the Registration Request message through the terminal's NAS (Non-Access-Stratum) and interface. Add the Mobile IAB service indication parameter to the Registration Request message to indicate that the Mobile IAB service is started.
2. The serving NG-RAN transmits a UL NAS transfer message to the AMF (Access and Mobility management Function) for a UE (User Equipment). The AMF-UE is an AMF connected to a serving NG-RAN and refers to a connection with the UE.
3. AMF-UE learns that the terminal starts the mobile IAB service through Mobile IAB service indication among the parameters in the Registration Request message, and sends a mobile IAB service request message to the AF (Application function) that manages the mobile IAB service.
4. AF sends a mobile IAB service response to AMF-UE. In 4a, if necessary, authentication and security procedures of the terminal are performed.
5. The AMF-UE receives a response to the service from the AF and sends a Registration Accept message to the serving NG-RAN through the DL NAS transfer message. AMF-UE confirms that the mobile IAB service is registered.
6. The serving NG-RAN transmits a Registration Accept message to the terminal.
7. Set a new user plane path of the terminal. At this time, information for connecting with the mobile IAB is provided to the terminal.
8. The terminal camps on using the configuration information of the mobile IAB received at No. 7.
9. The terminal continues to receive existing data services through mobile IAB.

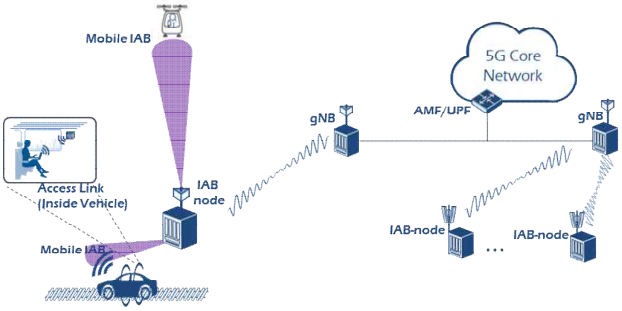

Fig.2. Architecture of mobile IAB system

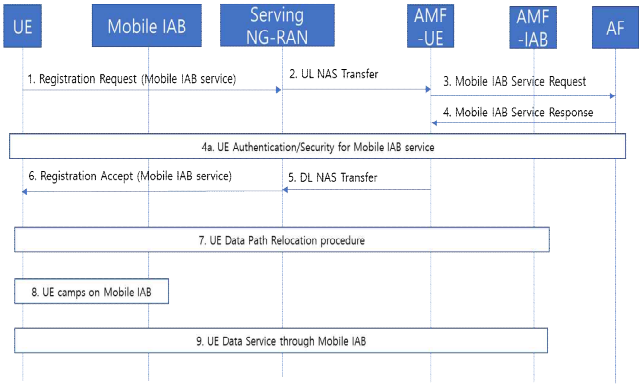

Fig.3. Mobile IAB service registration and service continuity procedure

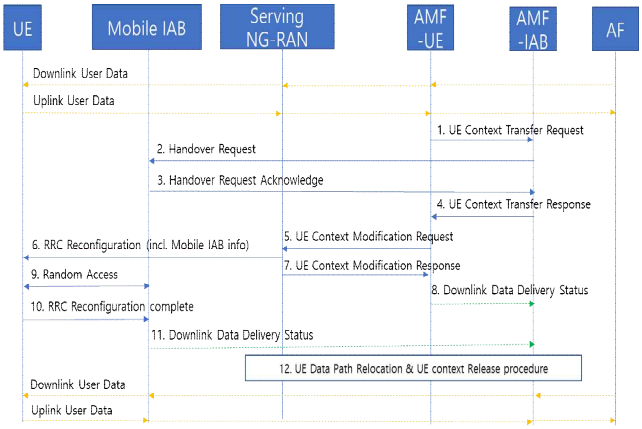

Fig.4. Data path Relocation procedure

Figure 4 proposes a procedure for data path relocation of user. The data path of the terminal is indicated by the yellow arrow in Figure 4 (data path through serving NG-RAN and AMF-UE). When a user boards a mobile IAB and goes up in the air, the data path connected from the ground base station must be changed to a mobile IAB. It is set differently from the conventional handover procedure.

1. Forward the UE Context Transfer Request message from AMF-UE to AMF-IAB. It delivers information on the terminal to be transferred to the mobile IAB (UE context: QoS, the bearer state currently in service, etc.). AMF-IAB refers to a connection with an AMF connected to a mobile IAB.

2. AMF-IAB delivers handover requests to mobile IAB. The AMF-IAB transmits the terminal context to the mobile IAB to notify that a new terminal is connected.

3. Mobile IAB delivers Handover Request Acknowledge to AMF-IAB. In this case, all mobile IAB configuration information (wireless channel configuration information, etc.) to be transmitted to the terminal is included and delivered.

4. AMF-IAB delivers mobile IAB-related configuration information to AMF-UE.

5. The AMF-UE delivers to the serving NG-RAN, including the contents received in the UE Context Modification Request message.

6. The serving NG-RAN delivers an RRC reconfiguration message to the terminal. The RRC Reconfiguration message includes all mobile IAB configuration information and the like.

7. The serving NG-RAN delivers a UE Context Modification Response message to the AMF-UE.

8. AMF-UE delivers the Downlink Data Delivery Status to AMF-IAB.

9. The terminal performs a mobile IAB campaign and performs a random-access procedure using the configuration information of the mobile IAB included in the RRC Reconfiguration message received in No. 6.

10. The terminal delivers the RRC Reconfiguration Complete message to the mobile IAB. As a result, the terminal is connected to the mobile IAB.

11. Deliver Downlink Data Delivery Status from Mobile IAB to AMF-IAB.

12. Completely change the path connected through the existing AMF-UE to AMF-IAB and proceed with deleting the UE context to the serving NG-RAN.

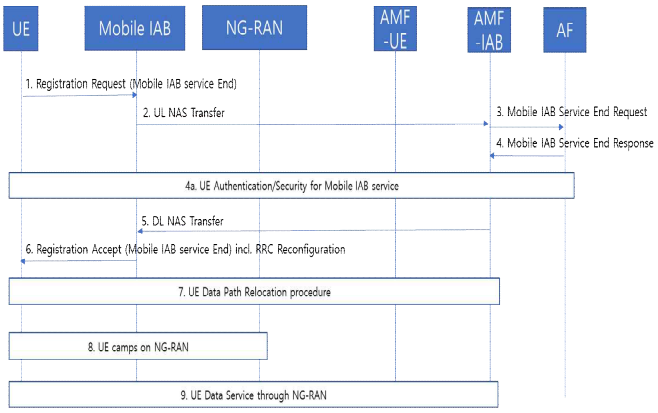

Fig.5. Mobile IAB service cancellation procedure

Figure 5 describes the procedure for terminating the service in the mobile IAB when a user in the UAM comes down to the ground.

1. Start the release process when the terminal gets off the mobile IAB. For example, tag when getting off a bus or train, or choose to terminate the service through mobile IAB through an app installed on the user's terminal. The terminal transmits a registration request message to the network as an example for starting the mobile IAB release procedure. Like the registration procedure, the mobile IAB service application of the terminal fills the Mobile IAB service indication parameter of the Registration Request with the Mobile IAB service end content through the interface with the NAS of the terminal.

2. Transfer UL NAS transfer message from mobile IAB to AMF-IAB.

3. Through the Registration Request message (Mobile IAB service indication parameter), the AMF-IAB learns that the terminal terminates the mobile IAB service and sends a mobile IAB service end request message to the Application function (AF) that manages the mobile IAB service.

4. AF sends a mobile IAB service end response to AMF-IAB. In 4a, if necessary, authentication and security procedures of the terminal are performed.

5. The AMF-IAB receives a message from the AF to cancel the service and sends a Registration Accept message to the mobile IAB via the DL NAS transfer message.

6. The mobile IAB transmits a Registration Accept message to the terminal.

7. Set a new user plane path of the terminal. In this case, information for connection with NG-RAN is provided to the terminal. It is similar to the data path relocation procedure described in Figure 7.

8. The terminal camps on the target NG-RAN using the NG-RAN configuration information provided in procedure 7.

9. The terminal continues to receive services through NG-RAN.

IV. Conclusion

In this paper, we have proposed several procedures for continuously providing services to users on a UAM equipped with a mobile IAB that moves in a three-dimensional space. The user will board the UAM, move from the ground to the three-dimensional space, and land on the ground. Assuming this scenario, we have focused on three procedures such as a procedure for users to start services according to UAM boarding, a procedure for continuously receiving services from ground base stations even in UAM in three-dimensional space, and a procedure for releasing UAM services when landing on the ground.

Acknowledgment

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