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Host Based Handover Approaches for Three-Tier NGN Architecture

P. Ravi Kiran[#],Y. K.Sundara Krishna[#]
[#]*Department OfComputer Science, Krishna University, Machilipatnam– Andhra Pradesh, INDIA*
Corresponding Author:P. Ravi Kiran

ABSTRACT: Next Generation Networks (NGN)has a major impact on existing communication technology. The main goal of Next Generation Networks is to give a greater flexibility to the users to access the desired services from the available heterogeneous networks at anytime, anywhere vigorously with the concept of generalized mobility. Mobility management is one of the crucial functions in NGN. It is very much essential to develop heterogeneous network compatibilities and modified mobility management functionalities to provide high QoS with seamless generalized mobility for NGN system. One of the major problems of NGN is to development of new architectural concepts, protocols and functionalities for mobility management to adopt generalized mobility in order to provide seamless services to NGN users. This paper aims to develop a novel architecture for NGN and proposes host based handover approaches.

Keywords:host based handover control, mobility management,generalized mobility, regional systems, heterogeneous networks.

I. INTRODUCTION

In the recent years, wireless networks such as UMTS, Wi-Fi, WiMAX and WCDMA/HSPA has encouraged the emergence of many services such as VOIP, FTP, video on demand, web applications etc. that takes the advantages of the mobility. However, a single technology can hardly satisfy all the services expectations. Therefore the integration of different wireless technologies in a heterogeneous environment offers best opportunity for services to be well served. NGN is urbanized to integrate heterogeneous wireless technologies that aim to provide guaranteed QoS [1][3][4]. One of the open problems in NGN is development of novel architectural concepts, protocols and functionalities mobility management to adopt generalized mobility in order to provide seamless services to NGN users [5]. The existing NGN is a two-tier architecture in which the access networks are connected to the core network such that all the mobility management activities are performed at the core level only [6]. This resembles the two tiers NGN as a centralized system. For scalability enhancement of mobility management in the NGN and to construct the NGN system with centralized control and decentralized process and computation, the functional architecture can be extended to the architecture with three levels [1]. This paper proposes three-tier architecture for NGN system. To address handover control operations in the proposed three-tier NGN system, it is requisite to define handover scenarios. The detailed host based handover functionalities for the identified handover scenarios at access network level to core level are discussed in this paper.

The rest of the paper is organized as follows. Section II proposes the three-tier novel architecture for NGN system. Section III discusses the features, characteristics and capabilities of the proposed three-tier NGN architecture. Different possible handover scenarios and effective handover scenarios for three-tier NGN architecture is discussed in section IV. Section V discusses the handover approaches for three-tier NGN architecture this section also defines the terminologies used in the approaches. The flowchart for handover operational sequence is also narrated in this section. Section VI narrates the proposed host based handover approaches for three-tier NGN system. Finally, section VII concludes with the advantages of proposed host based handover approaches for three-tier NGN system.

II. ARCHITECTURE OF THREE-TIER NGN

A three-tier novel architecture for NGN system is proposed to provide solutions to the critical issues of vertical handover. The architecture is developed by introducing a new layer, regional systems (RG) in between the core network and access networks of the existing NGN. The proposed three-tier NGN architecture is shown in Fig. 1.The three components of the proposed three-tier NGN system are as follows: 1) Core Network (CN) 2) Regional Systems (RG) 3) Access Networks (ANs). The CN and the ANs are the layers of the existing NGN system. The newly proposed layer is the Regional Systems (RG).

Core Network (CN): The core network is the IP based backbone network supports mobility across a variety of heterogeneous access networks in NGN.

Regional Systems (RG): The regional systems are introduced in the novel architecture of the NGN system. The regional systems are regional level servers that act as auxiliary to the core network. They are also IP based systems that support mobility across variety of heterogeneous access networks in NGN.
Access Networks (ANs): Access network is a network that is characterized by a specific wired/wireless access technology. The underlying physical connection method for a radio based communication is defined as a radio access technology. E.g. are Cellular 2G, Cellular 3G, Cellular 4G, WLAN, WMAN, WPAN etc.

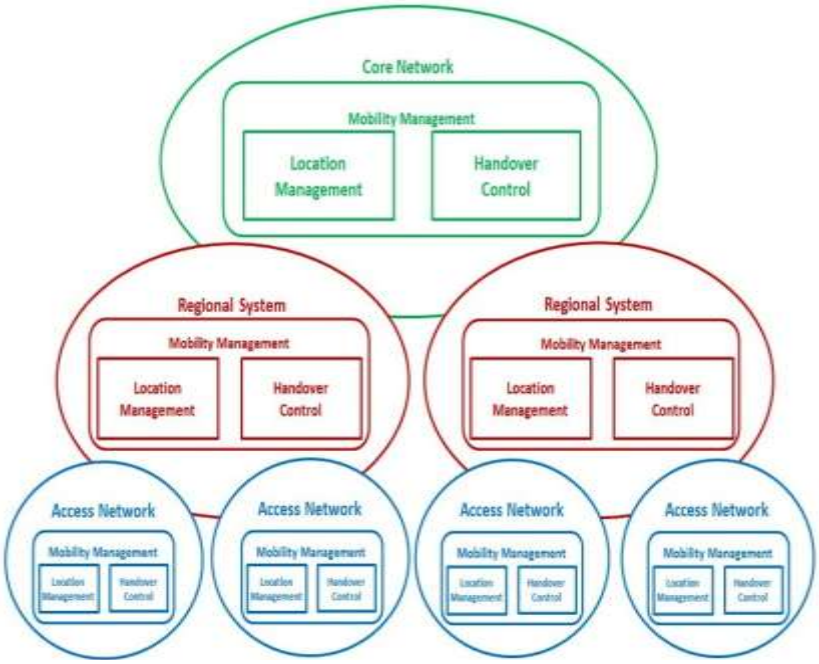

Fig. 1. Three-Tier Novel Architecture for NGN System

III. FEATURES, CHARACTERISTICS AND CAPABILITIES OF THREE-TIER NGN

The key features of the proposed three-tier NGN architecture grasps the basic features of NGN and are quantified as follows:

- The mobility management functionalities can carry out in three tiers of the NGN system and are supported in a distributed environment.
- The core level activities of mobility management are decentralized to perform at regional systems level also.
- The handover functionalities are distributed among three levels to minimize complexities.
- The location management activities are circulated among three tiers to maintain integrity in the three-tier NGN system.

Along with the existing characteristics and capabilities, the three-tier NGN architecture is provided with the following characteristics and capabilities:

- The three-tier NGN architecture is facilitated with centralized control and decentralized process and computing system.
- As the three-tier NGN system is having three layers and hence the handover functionalities are distributed in three levels.
- The proposed architecture is capable of handling more number of systems.

Three tiers NGN support regional level compatible computing applications.

IV. HANDOVER SCENARIOS FOR THREE-TIER NGN

In three-tier NGN architecture, mobile user equipment is connected to the core network through access networks via regional systems. While these mobile user equipment are moving, the connectivity of mobile user equipment will be changed to another access network belongs to same regional system or different regional system of same core network or different core networks. Considering the structuring nature of the access networks, one can view 15 theoretical scenarios for handover management. For each level two cases are possible i.e., either intra handover or inter handover. For these cases at each level there may be homogeneous or

heterogeneous access networks, regional systems or core networks. Table 1 shows 15 theoretical scenarios for three-tier NGN system [2][9].

A. Effective Handover Scenarios for NGN

There are 15 possible scenarios that are observed in handover considering inter and intra domains and homogeneous and heterogeneous systems. Further it is observed that the functionalities of certain scenarios are implicitly available in some other scenarios. In particular, heterogeneous based scenarios implicitly support the functionalities required for homogeneous scenarios. In such cases the approaches developed for heterogeneous scenarios are sufficient to address implicitly inbuilt other scenarios. In simple terms one can say that 15 theoretical scenarios can be reduced to 4 practical scenarios addressing all possibilities. Table 2 shows the list of effective handover scenarios for NGN.

After keenly analyzing the 15 handover scenarios for NGN, it is identified that high level inter obsoletes low level handovers. From scenario 2 and 3, the high level inter access networks obsoletes the type of access network through which the handover occurs, results in an effective handover "Intra Core, Intra Region, Inter Access". From scenarios 4, 5, 6 and 7, the high level inter region obsoletes the type of regional systems and type of low level access networks through which the handover occurs, results in an effective handover "Intra Core, Inter Region, Inter Access". Similarly from scenarios 8, 9, 10, 11, 12, 13, 14 and 15, the high level inter core network obsoletes the type of core network, type of low level regional systems and type of low level access networks through which the handover occurs, results in an effective handover "Inter Core, Inter Region, Inter Access" [9][10].

S. No.	Handover Scenarios	Type of Handover
1	Intra Core, Intra Region, Intra Access	No Handover
2	Intra Core, Intra Region, Inter Access of similar type	Horizontal
3	Intra Core, Intra Region, Inter Access of different type	Vertical
4	Intra Core, Inter Region of similar type, similar ANs	Horizontal
5	Intra Core, Inter Region of similar type, different ANs	Vertical
6	Intra Core, Inter Region of different type, similar ANs	Vertical
7	Intra Core, Inter Region of different type, different ANs	Vertical
8	Inter Core of similar type, similar Regions, similar ANs	Horizontal
9	Inter Core of similar type, similar Regions, different ANs	Vertical
10	Inter Core of similar type, different Regions, similar ANs	Vertical
11	Inter Core of similar type, different Regions, different ANs	Vertical
12	Inter Core of different type, similar Regions, similar ANs	Vertical
13	Inter Core of different type, similar Regions, different ANs	Vertical
14	Inter Core of different type, different Regions, similar ANs	Vertical
15	Inter Core of different type, different Regions, different ANs	Vertical

Table 1. 15 Theoretical Handover Scenarios for NGN

Effective Scenario No.	Existing Handover Scenarios	Effective Handover Scenarios
Scenario 1	Scenario 1	Intra Core, Intra Region, Intra AN
Scenario 2	Scenario 2 & 3	Intra Core, Intra Region, Inter AN
Scenario 3	Scenario 4, 5, 6 & 7	Intra Core, Inter Region, Inter AN
Scenario 4	Scenario 8, 9, 10, 11, 12, 13,14 & 15	Inter Core, Inter Region, Inter AN

Table 2. Effective Handover Scenarios for NGN

The structural representation of these four effective scenarios is shown in Fig. 2, Fig. 3, Fig.4 and Fig. 5.

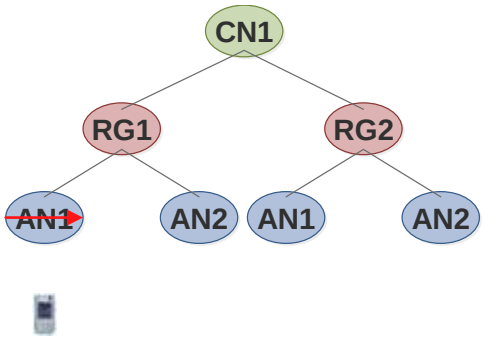

Fig. 2. Effective Handover Scenario 1 – Intra Core Intra Region Intra AN

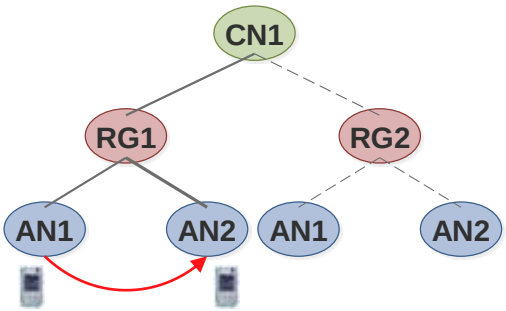

Fig. 3. Effective Handover Scenario 2 – Intra Core Intra Region Inter AN

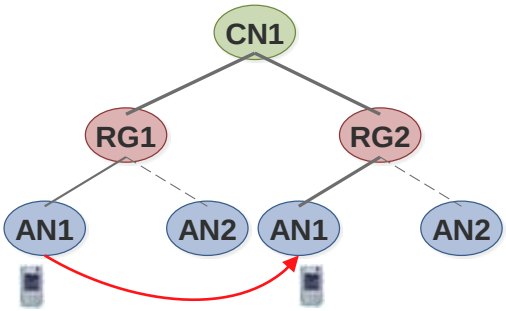

Fig. 4. Effective Handover Scenario 3 – Intra Core Inter Region Inter AN

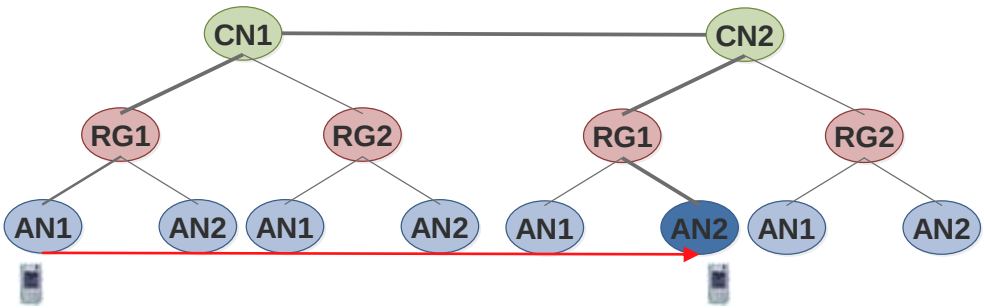

Fig. 5. Effective Handover Scenario 4 – Inter Core Inter Region Inter AN

The first three levels of these structural trees are static in nature, fourth level is totally dynamic in nature thus the topological structure of three-tier NGN architecture is semi dynamic in nature. Handling dynamic nature at fourth level i.e. mobile user equipment level is crucial. The handling of dynamic nature of fourth level is technically called as handover process. The following section 5.4 describes handover approaches for three-tier NGN architecture pertaining to these 4 effective handover scenarios.

V. HANDOVER APPROACHES FOR THREE-TIER NGN ARCHITECTURE

The mobility management process in three-tier NGN architecture consists of operations viz. initial connection establishment and handover. These two operations performs the two sub functionalities of mobility management namely location management and handover of control. The operation initial connection establishment i.e. location management function of mobility management registers permanent location ID (PLID) of mobile user equipment in the central registry in three-tier NGN architecture. The handover function

of mobility management pertaining to initial connection establishment establishes a data tunnel between regional systems and access network to which mobile user equipment is attached. The handover operation of mobility management is performed in handover process.This paper proposed two handover approaches for three-tier NGN architecture. Usually the handover process is initiated either by mobile or network; (1) Host based handover approach (2) Network based handover approach.

In host based handover approach, the handover process is initiated by mobile user equipment. Based on the establishment of tunnel, the host based handover approach can be performed in two cases: (a) Generic host based handover control (b) Handover control based on handover tunnel. In generic host based handover control, the data tunnel will be established either between mobile user equipment connected access network handover control and core network handover control (AHC-CHC) or between mobile user equipment connected access handover control and regional systems handover control (AHC-RHC). The data tunnel establishment is purely depending on the type of effective handover scenarios. To reduce the packet loss during handover, the host based handover approach is proposed with alternate way of establishing tunnel and this tunnel is called handover tunnel. In handover control based on handover tunnel, the handover tunnel is established between old access network handover control and new access network handover control (old AHC – new AHC).

In network based handover approach, the handover process is initiated by the access network handover control to which the mobile user equipment is connected. The network based handover approach can also be performed in two cases: (a) Handover control based on LBU operation (b) Handover control based on LBU notification. In network based handover control based on LBU operation, the handover procedure performs in a tightly coupled manner. The data tunnel will be established either between mobile user equipment connected access network handover control and core network handover control (AHC-CHC) or between mobile user equipment connected access handover control and regional systems handover control (AHC-RHC). The data tunnel establishment in this approach is also purely depending on the type of effective handover scenarios. To avoid bottleneck at core network level, the proposed network based handover approach based on LBU notification is establishing data tunnel directly between mobile user equipment connected access network handover control and corresponding user equipment connected access network handover control.

The initial connection establishment procedure requires authentication of mobile user equipment before the mobile user equipment is initially connected to access network. This operation is called initial authentication, which will be performed with AAA server. The handover control operation also requires authentication of mobile user equipment before the mobile user equipment is handover to new access network. This operation is called as pre-authentication operation and is also performed with the AAA server.This paper describes the proposed handover approaches for three-tier NGN architecture in host initiated handover environment. The proposed approaches explains initial connection establishment and the proposed handover approaches for the four effective handover scenarios [8][10].

A. Notations and Terminology

Initial Connection Establishment: When mobile user equipment is first attached to an access network, the location management operation, location binding update registers permanent location ID (PLID) of mobile user equipment in the central registry of NGN and establishes an initial data tunnel between central handover control and access network handover control to deliver packets to the mobile user equipment.

Data Tunnel: Tunnel is an IP-in-IP encapsulation mechanism of delivering data packets between two endpoints controlled by handover control of core, region or access network.

Handover Tunnel: Handover tunnel is also a data tunnel established between two endpoints controlled by handover control as an alternative approach used to minimize the data packet loss during handover.

Permanent Location ID (PLID): The location ID that does not change even when a mobile user equipment move across different access networks or IP subnets.

Temporary Location ID (TLID): The location ID that changes when mobile user equipment moves across different access networks or IP subnets.

Location Binding Update (LBU): Location binding update is an operation of location management to manage the mapping between temporary location IDs (TLIDs) and permanent location IDs (PLIDs).

Location Binding Update Request: $LocationBindingUpdateRequest$ is a message for requesting to perform mapping between temporary location ID (TLID) and permanent location ID (PLID) by location management process at different levels.

Location Binding Update Response: $LocationBindingUpdateResponse$ is a response message generated when a mapping between temporary location ID (TLID) and permanent location ID (PLID) is performed by location management process at different levels.

Location Binding Update Notification: $LocationBindingUpdateNotification$ is a notification message sends by present access network handover control process of mobile user equipment (MUE's AHC) or its core network handover control process (MUE's CHC), notifying to the access network handover control process of

corresponding user equipment (CUE's AHC) that the mobile user equipment changed its point of attachment i.e. a new temporary location ID (new TLLD) is mapped with the permanent location ID (PLID) of mobile user equipment (MUE).

Location Binding Update Confirm: $LocationBindingUpdateConfirm$ is a confirmation message generated by access network handover control process of corresponding user equipment (CUE's AHC) with respect to the notification message and reply back to present access network handover control process of mobile user equipment (MUE's AHC) or its core network handover control process (MUE's CHC).

ALM Discovery/Change: In host based handover approach, the access network location management broadcast router advertisement message. When mobile user equipment (MUE) first attach to an NGN, it will be discovered by an access network and it is called $ALMDiscovery$. For the next time, when mobile user equipment (MUE) enters to new access network region, it will be discovered by an access network and it is called $ALMChange$.

Tunnel Request/Response: In host based or network based handover approaches, to establish one endpoint of a data tunnel or handover tunnel by the handover control process, the location management process at access network, regional systems or core network level generates a message called $TunnelRequest$ and send it to its respective handover control process. The handover control process intern replies to the location management process via $TunnelResponse$ message.

Tunnel Update/Response: In host based or network based handover approaches, to update one endpoint of a data tunnel or handover tunnel by the handover control process, the location management process at access network, regional systems or core network level updates using a message $TunnelUpdate$ and send it to its respective handover control process. The handover control process interns replies to the location management process via $TunnelResponse$ message.

B. Flowchart for Handover Operational Sequence

When a mobile is powered on, it will perform the initial attachment process. The mobile periodically scans for potential attachment points i.e. access points through which the mobile can connect to the access networks that are available. The process of discovering the attachment points by the mobile is called network discovery. Once the selection of the target access point is done, the mobile registers with the target access network. This process is called location registration. At the end of these processes, IP connectivity is established between the mobile user equipment and the network [7].

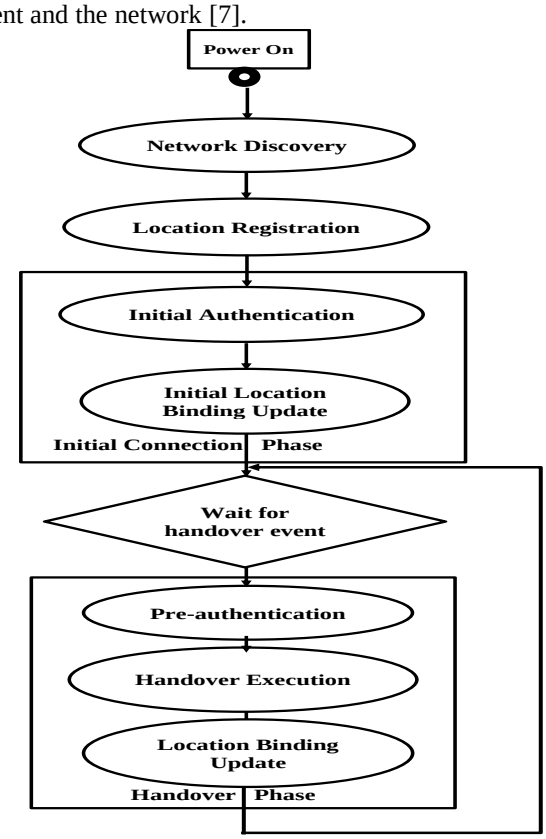

Fig. 6. Flowchart for Handover Operational Sequence in Three-Tier NGN

During the initial authentication, the mobile user equipment performs authentication with the AAA server. The initial location binding update operation binds the mobile user equipment permanent location ID (PLID) with the central registry in the NGN. These two processes will be performed for the first time and is

named under initial connection phase. The following section describes the approaches for establishing of initial data tunnel in host based handover in three-tier NGN. The operations on the handover phase will be performed when a handover event occurs. The handover event occur either due to lack of connectivity / service from the existing access network to which the mobile user equipment is connected or due to the availability of better connectivity / service from other access networks. Sometimes, the mobile user equipment can initiate an event for handover. Once the handover event occurs, the mobile user equipment performs authentication with the AAA server of the newly connected access network and is called pre-authentication. For fast handover pre-authentication will be performed with all the available access networks.

The location binding update operation in handover phase performs updating or binding of temporary location ID (TLID) with the permanent location ID (PLID). During the handover execution, the mobile user equipment or its newly connected access network establishes new data tunnel with existing core network handover control or regional handover control to deliver the packets to the mobile user equipment via newly connected access network. The flowchart for handover operational sequence in three-tier NGN is shown in Fig. 6. The following section describes host based approach for establishing data tunnels during handover for four effective handover scenarios [10].

VI. HOST BASED HANDOVER CONTROL APPROACHES FOR THREE-TIER NGN

In host based handover scheme, the mobile user equipment initiates the handover control operations. The mobile user equipment performs the location binding update operations with an associated location management as soon as a handover between different access network handover control regions are detected. This paper proposes two different approaches in host based handover control for establishing data tunnel to deliver packets destined to the mobile user equipment, and are as follows: (a) Generic host based handover control approach (b) Handover control approach based on handover tunnel.

This section preliminarily describes the initial connection establishment for generic host based handover control approach. Later, the two proposed host based handover control approaches are narrated for inter AN, inter region and inter core effective handover scenarios. It may be noted that, as there is no handover for intra AN effective handover scenario, only the initial connection establishment will be performed and the proposed handover control approaches are not applicable.

A. Initial Connection Establishment for Generic Host Based Handover Control Approach

Fig. 7 illustrates an information flow to handle the mobile user equipment's initial connection establishment to three-tier NGN system based on host initiated handover scheme. The flow in the figure shows the case in which data tunnel for mobile user equipment (MUE) is established between two endpoints controlled by regional systems handover control (RHC) and access network handover control (AHC). To simplify the description, all the endpoints are illustrated as handover control functional entities. However, the real endpoints of a tunnel are transport functions of three-tier NGN system controlled by those handover control functional entities. This simplification will be applied to all the figures in this paper.

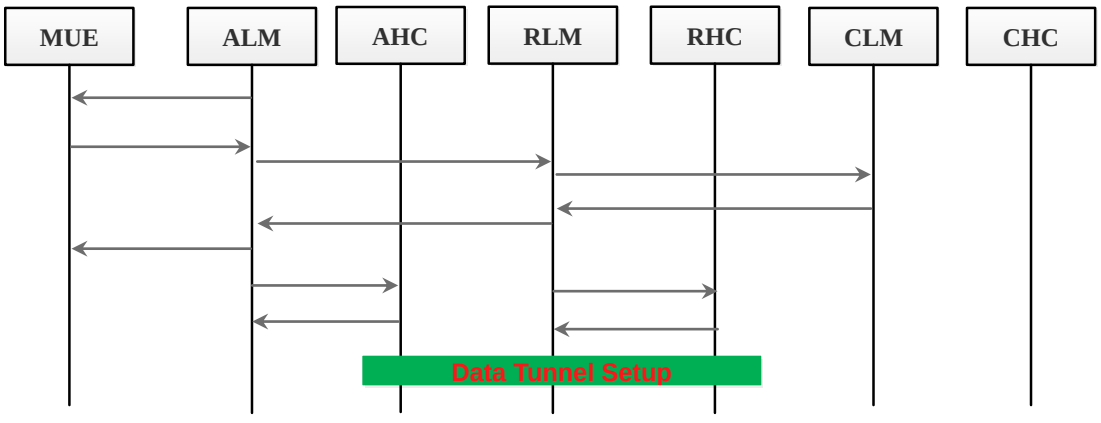

Fig. 7. Host Based HC Approach – Initial Connection Establishment

In Fig. 7, when an MUE is first attached to an NGN, it will discover an access network closest to MUE for communication. MUE discovers ALM for initial location binding update by using router advertisement

message. Then the MUE initiates the location binding update procedure by sending $LocationBindingUpdateRequest$ to ALM. The ALM forwards the $LocationBindingUpdateRequest$ message to the RLM to create the binding information of the MUE. RLM transmits binding information to MUE as $LocationBindingUpdateResponse$ message via ALM. After transmitting$LocationBindingUpdateResponse$ message by the RLM, the RLM and RHC exchange$TunnelRequest$and $TunnelResponse$ messages with each other. This exchange process request the transport functions of NGN to setup an endpoint for data tunnel at one end. After receiving $LocationBindingUpdateResponse$ message from RLM, ALM and AHC exchange $TunnelRequest$ and $TunnelResponse$ messages to establish another endpoint for data tunnel. Now the data packets can be delivered to the MUE through the data tunnel between RHC and AHC.

B. Handover Procedure for Generic Host Based Handover Control Approach

The handover procedure for generic host based handover control approach performs differently for inter AN, inter region and inter core effective handover scenarios. This section describes the handover procedure for the three effective handover scenarios in detail.

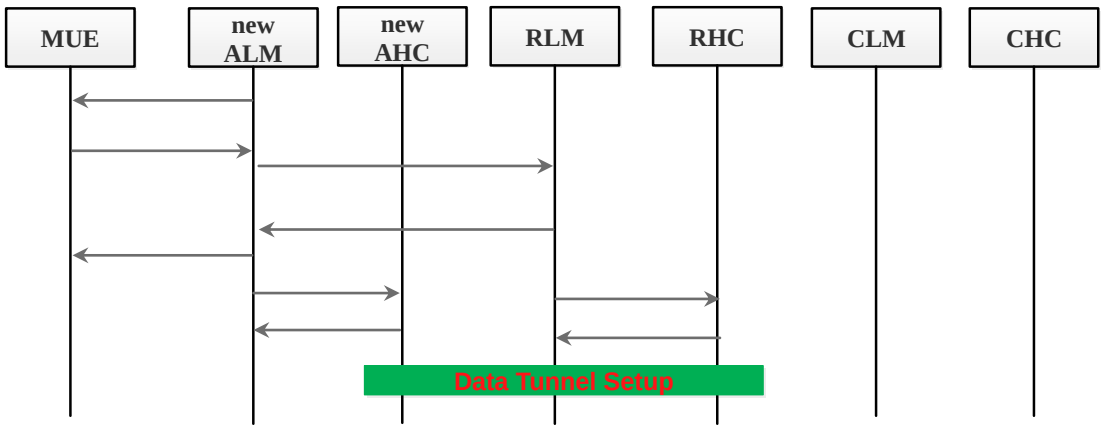

Fig. 8. Host Based HC Approach – Generic Connection Establishment for Inter AN Handover Scenario

In inter AN effective handover the mobile user equipment is moving between two access networks and within the same region and core. For this scenario based on the initial connection establishment, the handover procedure is illustrated as follows. Fig. 8 illustrates the data flow in controlling MUE's handover between two access networks within the same regional system based on the generic host based handover control approach. The figure also describes the procedure to establish data tunnel between two distinct endpoints controlled by RHC and AHC. The flow in Fig. 8 is similar to that of initial connection establishment procedure, but $ALMDiscovery$ message is replaced with $ALMChange$ message and the $TunnelRequest$ message is replaced with $TunnelUpdate$ message. The $TunnelUpdate$ message is similar to $TunnelRequest$ message but contains information to differentiate the handover situation from initial connection situation. When RLM receives $LocationBindingUpdateRequest$message from MUE via new ALM, RLM updates the location binding information of MUE with newly assigned location ID. $TunnelUpdate$&$TunnelResponse$ messages exchanged between RLM and RHC updates the data tunnel information so that new data tunnel is bound by the MUE. $TunnelUpdate$&$TunnelResponse$ messages exchanged between new ALM and AHC are similar to those performed in initial connection establishment procedure. Now the data packets destined to MUE can be delivered through the new data tunnel between RHC and new AHC.

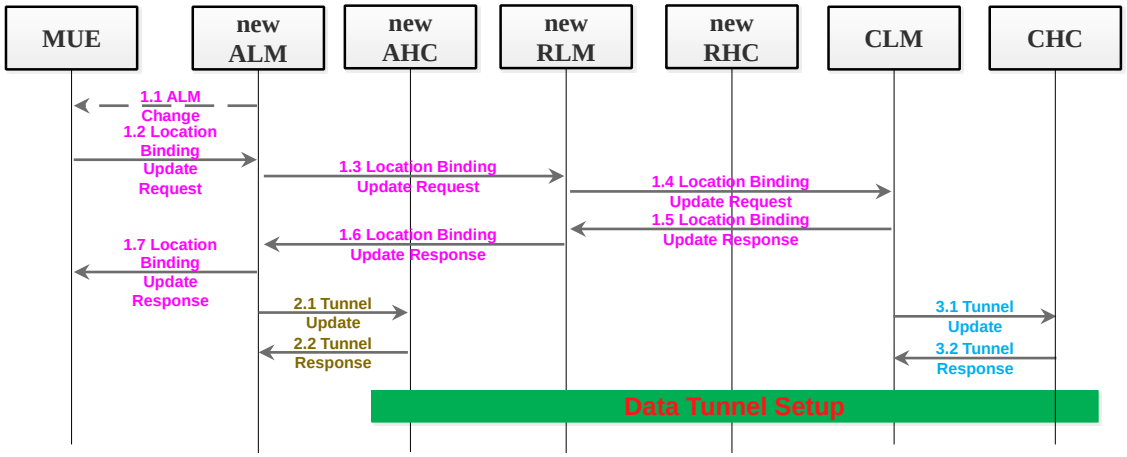

Fig. 9. Host Based HC Approach – Generic Connection Establishment for Inter Region Handover Scenario

In inter region effective handover the mobile is moving between two access networks of two regions and within the core. Similar to intra core intra region inter AN, in this scenario also the handover procedure is performed by considering initial connection establishment with the data tunnel between mobile user equipment connected access network handover control and core network handover control. Fig. 9 illustrates the data flow in controlling MUE's handover between two regional systems of same core network based on generic host based handover control approach. The figure also describes a procedure to establish data tunnel between two distinct endpoints controlled by CHC and new AHC. The flow in Fig. 9 is similar to that of initial connection establishment procedure, but $ALMDiscovery$ is replaced with $ALMChange$ and the $TunnelRequest$ message is replaced with $TunnelUpdate$ message. The $TunnelUpdate$ message is similar to $TunnelRequest$ message but contains information to differentiate the handover situations from initial connection situation. When CLM receives$LocationBindingUpdateRequest$ message from MUE via new ALM and new RLM, CLM updates the location binding information of MUE with newly assigned location ID. The CLM replies with $LocationBindingUpdateResponse$ message to MUE via new ALM and new RLM. $TunnelUpdate$&$TunnelResponse$ messages exchanged between RLM and RHC updates the data tunnel information so that new data tunnel is bound by the MUE. $TunnelUpdate$&$TunnelResponse$ messages exchanged between new ALM and new AHC are similar to those performed in initial connection establishment procedure. Now the data packets destined to MUE can be delivered through the new data tunnel between CHC and new AHC.

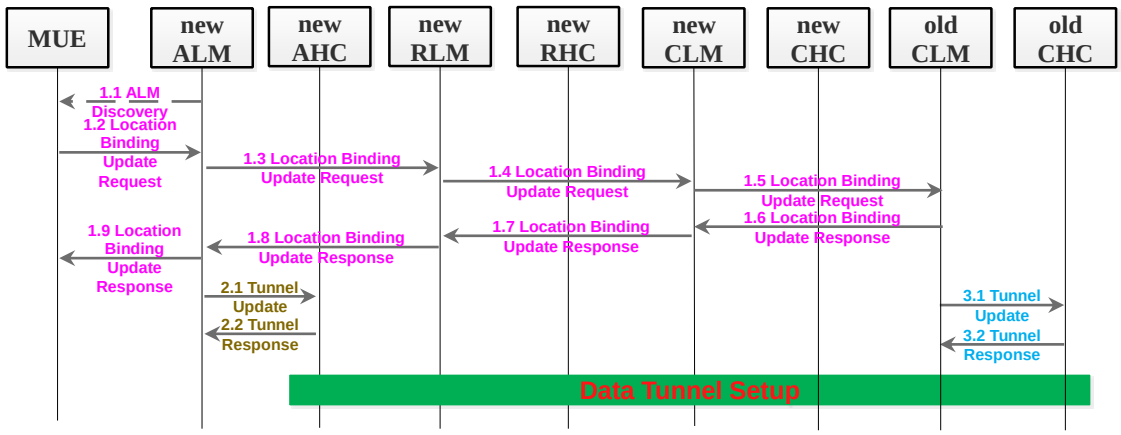

Fig. 10. Host Based HC Approach – Generic Connection Establishment for Inter Core Handover Scenario

In inter core effective handover the mobile is moving from one NGN to another NGN. In this scenario the access networks, regional systems and the core networks are changed. Similar to intra core inter region inter AN, in this scenario also the handover procedure is performed by considering initial connection establishment with the data tunnel between mobile user equipment connected access network handover control and core network handover control. Fig. 10 illustrates the data flow in controlling MUE's handover between two core network regions based on generic host based handover control approach. The figure also describes a procedure to establish data tunnel between two distinct endpoints controlled by new CHC and new AHC. The flow in Fig. 10 is similar to that of initial connection procedure, but ALM Discovery is replaced with ALM Change message

and the *TunnelRequest* message is replaced with *TunnelUpdate* message. The *TunnelUpdate* message is similar to *TunnelRequest* message but contains the information to differentiate the handover situation from the initial connection situation.When old CLM receives *LocationBindingUpdateRequest* message from MUE via new RLM and new ALM, new CLM updates the location binding information of MUE with newly assigned location ID. The new CLM replies with *LocationBindingUpdateResponse* message to MUE via new RLM and new ALM. *TunnelUpdate*&*TunnelResponse* messages exchanged between old CLM and old CHC updates the data tunnel information so that new data tunnel is bound by the MUE. *TunnelUpdate*&*TunnelResponse* messages exchanged between new ALM and new AHC are similar to those performed in initial connection establishment procedure. Now the data packets destined to MUE can be delivered through the new data tunnel between old CHC and new AHC via new RHC and new AHC.

C. Handover Procedure for Handover Control Approach based on Handover Tunnel

To minimize data packet loss during a handover, a handover procedure for handover control approach based on handover control is performed. Old AHC and new AHC involved in the handover need to establish the handover tunnel. The MUE has to perform location binding update procedure by interacting with the relevant ALM in order to establish the handover tunnel between old AHC and new AHC, as it cannot directly interact with RLM or CLM. To setup or update the handover control the two AHCs has to exchange control messages. The initial connection establishment procedure of the MUE follows the generic information flow presented in Fig. 7. The signaling operations performed to establish a handover tunnel between two neighboring AHCs in inter AN, inter region and inter core effective handover scenarios are described below.

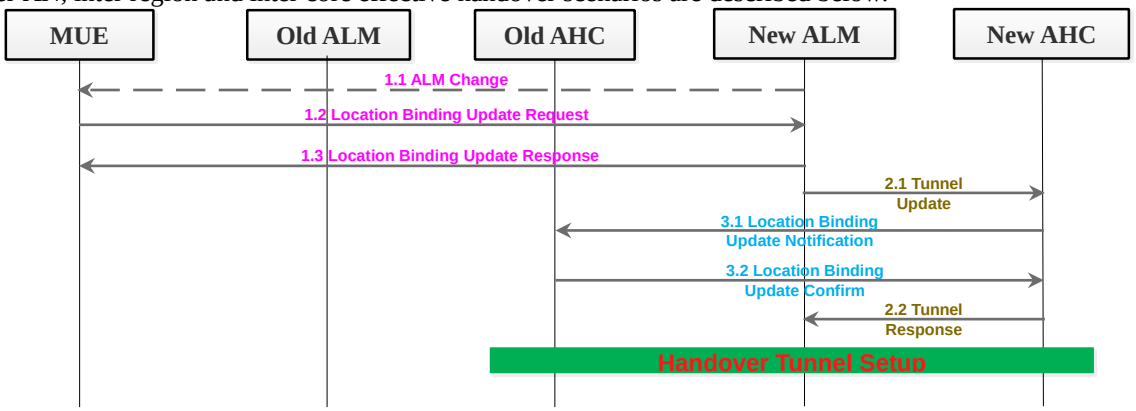

Fig. 11. Host Based HC Approach based on Handover Tunnel – Handover Tunnel Establishment for Inter AN Handover Scenario

In inter AN effective handover scenario, the mobile user equipment was originally located at old AHC region and then moves into new AHC region. Both the access networks between which the handover tunnel is established are under same regional system and core network. Fig. 11 illustrates the data flow in handling the handover tunnel for MUE between old AHC and new AHC. The mobile user equipment initiates the location binding update procedure by sending a *LocationBindingUpdateRequest* message to new ALM. The message contains the information to inform the new ALM that the MUE has moved from the region of old AHC to the region of new AHC. After receiving *LocationBindingUpdateRequest* message, the new ALM replies with *LocationBindingUpdateResponse* message. Then the new ALM sends *TunnelUpdate* message to new AHC to establish handover tunnel. After receiving *TunnelUpdate* message by new AHC, it requests the NGN transport functions to setup an endpoint for handover tunnel. The new AHC notifies the same by sending *LocationBindingUpdateNotification* message to old AHC via RHC. After receiving *LocationBindingUpdateNotification* message by old AHC, the old AHC requests the NGN transport functions to setup another endpoint for handover tunnel with old AHC. Thereafter, data packets delivered to old AHC are forwarded to new AHC through handover tunnel. Subsequently the new AHC forward the packets to the MUE.

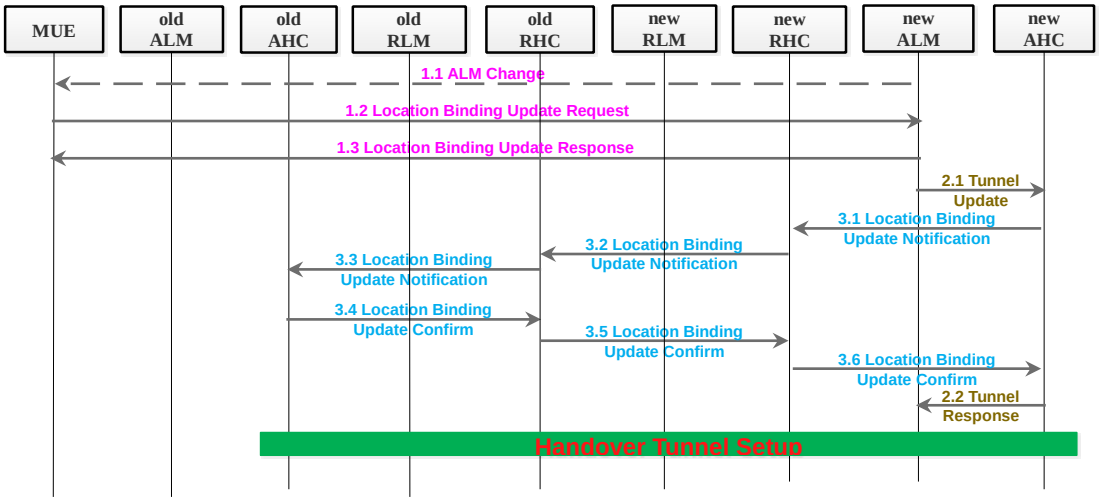

Fig. 12. Host Based HC Approach based on Handover Tunnel – Handover Tunnel Establishment for Inter Region Handover Scenario

In inter region effective handover scenario, the mobile user equipment was originally located at old AHC region and then moves into new AHC region. Both the access networks are located in different regional systems but under same core network. Fig. 12 illustrates the data flow in handling the handover tunnel for MUE between old AHC and new AHC in inter region effective handover scenario. The MUE initiates the LBU procedure by sending a *LocationBindingUpdateRequest* message to new ALM. The message contains the information to inform the new ALM that the MUE has moved from the region of old AHC of old RHC to the region of new AHC of new RHC. After receiving *LocationBindingUpdateRequest* message, the new ALM replies with *LocationBindingUpdateResponse* message. Then the new ALM sends *TunnelUpdate*message to new AHC to establish handover tunnel. After receiving *TunnelUpdate* message by new AHC, it requests the NGN transport functions to setup an endpoint of the handover tunnel. The new AHC notifies the same by sending *LocationBindingUpdateNotification* message to old AHC via new RHC, CHC and old RHC. After receiving *LocationBindingUpdateNotification* message by old AHC, the old AHC requests the NGN transport functions to setup another endpoint for handover tunnel with old AHC. Thereafter, data packets delivered to old AHC are forwarded to new AHC through handover tunnel. Subsequently the new AHC forward the packets to the MUE.

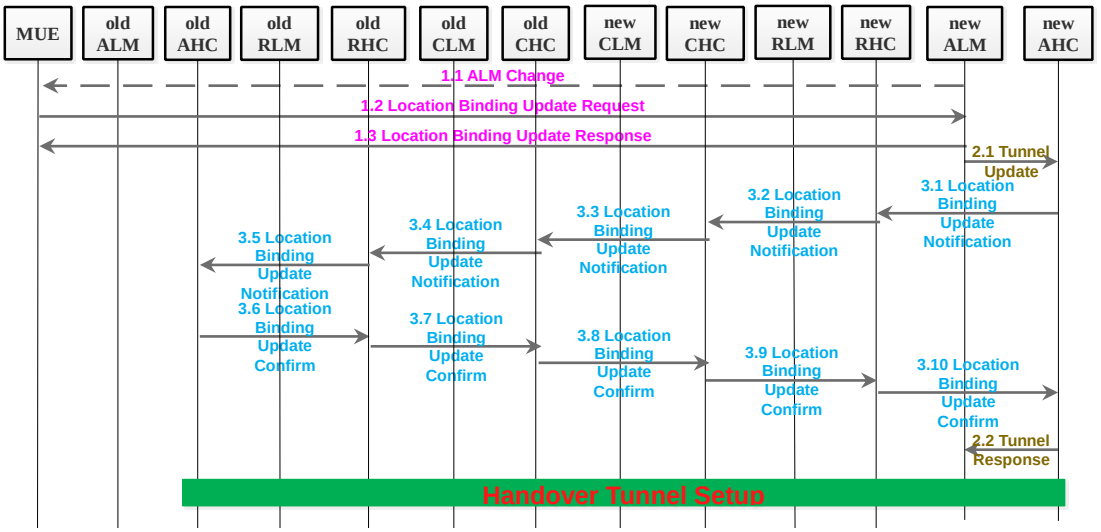

Fig. 13. Host Based Handover Control Approach based on Handover Tunnel – Handover Tunnel Establishment for Inter Core Handover Scenario

In inter core effective handover scenario, the mobile user equipment was originally located at old AHC region of one NGN and then moves into new AHC region of another NGN. Both the access networks are located in different regional systems and different core networks. Fig. 13 illustrates the data flow in handling the handover tunnel for MUE between old AHC and new AHC in inter core effective handover scenario. The MUE

initiates the LBU procedure by sending a $LocationBindingUpdateRequest$ message to new ALM. The message contains the information to inform the new ALM that the MUE has moved from the region of old AHC of old CHC to the region of new AHC of new CHC.After receiving $LocationBindingUpdateRequest$ message, the new ALM replies with $LocationBindingUpdateResponse$ message. Then the new ALM sends a $TunnelUpdate$ message to new AHC to establish handover tunnel. After receiving the $TunnelUpdate$ message by new AHC, it requests the NGN transport functions to setup an endpoint for handover tunnel. The new AHC notifies the same by sending $LocationBindingUpdateNotification$ message to old AHC via new RHC, new CHC, old CHC and old RHC. After receiving $LocationBindingUpdateNotification$ message by old AHC, the old AHC requests the NGN transport functions to setup another endpoint for handover tunnel with old AHC. Thereafter, data packets delivered to old AHC are forwarded to new AHC through handover tunnel. Subsequently the new AHC forward the packets to the MUE.

VII. CONCLUSIONS

The three-tier NGN architecture with regional systems is a novel development that is capable of providing solutions required for realizing some of the views and visions of NGN, in particular for developing sophisticated mobility management system. The handover process for three-tier NGN system is defined. The mobility management handover scenarios pertaining to terminal mobility of three-tier NGN are identified. Host based handover approachesfor three-tier NGN architecture is discussed in detail.

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BIOGRAPHIES

P. Ravi Kiran received hisPh.D. degree from Krishna University, Machilipatnamin 2017. He is currently working as an Assistant Professor & HOD in Department of Computer Science & Engineering, Srikalahasteeswara Institute of technology, Srikalahasti. His areas of interests are Mobile Computing, Service Oriented Architecture, Wireless Networks and Information Security. He is working with International Telecommunications Union (ITU): Y. 2018 recommendation series Y: Global Information Infrastructure, Internet Protocol aspects and NGN.

Y.K. Sundara Krishna qualified in Ph.D in Computer Science & Engineering from Osmania University, Hyderabad. Now, he is working as Professor in the Department of Computer Science, Krishna University, and Machilipatnam. His research interests are Mobile Computing, Service Oriented Architecture and Geographical Information Systems and having practical work experience in the areas of Computing Systems including Developing of Simulators for Distributed Dynamic Cellular Computing Systems, Applications of Embedded & Win32 clients, Maintenance of Multi-user System Software. Also he is working with International Telecommunications Union (ITU): Y. 2018 recommendation series Y: Global Information Infrastructure, Internet Protocol aspects and NGN.

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