Seamless Vertical Handover in Software Defined Radio Terminal

Hwan-Souk Yoo[1], Byungjoo Park[3*], and Sang-Ha Kim[2]

[1]Chungnam National University, Daejeon, Korea[1,2]
[3]Hannam University, Daejeon, Korea[3]
[*]Correspondent Author
grep@cclab.cnu.ac.kr[1], shkim@cnu.ac.kr[2], bjpark@hnu.kr[3]*

Abstract

Recently, through the development of the mobile network, a user was offered various services. The SDR technology is accessible to various mobile networks in the environment. In various wireless network services such as the ubiquitous and Convergence environment, it can provide the user an optimum radio environment. It is acceptable the various services like this as the SDR terminal of one through the Waveform Application, and more developed wireless network technique is applicable. Particularly, the processing speed of a processor developed exponentially with the growth of the semi-conductor technology. Furthermore, as the conversion technique between the digital signal and the analog signal developed rapidity, the introduction of SDR was available in the high speed data transfer system including 3rd generation wireless internet service. It has to be seamless vertical handover executable so that the SDR terminal can provide internet access service in which it is various to a user. In this research, we propose a method for supporting the Seamless VHO in the SDR terminal and the VHO-SCA for interoperate a SDR Middleware and IEEE 802.21 MIH.

1. Introduction

The SDR technology provides the flexible service, in addition it is possible to transplant the upgrade technology and performance as the open architecture signal processing technique which the SDR technology can reconstruct to the application software (wireless protocol standard) in which a user wants in one common hardware platform in order to manage with the various wireless communications networks (the multi-mode, multi-standard, multi-band, multi-function) flexibly in the multiple normalizing era. Particularly, the frequency use efficiently increases and an improvement and QoS base service providing of QoS will be possible.

The SDR technology introduces the open architecture to the programmable digital radio and maintains an independency between each function module (the hardware, and the software) as to all kinds of modeled device implementation. Since providing hardware reconfiguration ability, software programmability, flexibility, an expandability, and etc, it is expected to form the new framework of the wireless telecommunications installation implementation in the future. The SDR technology owes to the growth of the semi-conductor technology and the applicability gradually widens. And the SDR technology applies the SDR technology to the future to 4th generation mobile communications system and can connect most of wireless telecommunications systems with the reconfigurable terminal. As to this SDR technology, the application was applied to the military and the commercial product.

Because of working in the environment in which the various services like the convergence network environment is provided, the SDR terminal in which it is various Waveforms able to use has the suitable structure. By using the SDR terminal of one, a user can be offered the wireless communication service of an optimum from the location of a self.

For this, The SDR terminal has to reconfigure the Waveform in which it is optimally available in the current location. For this, the optimally usable Waveform is automatically discovered and it can announce to a user. The change mode the SDR terminal can be performed through the Reconfiguration process as the discovered Waveform.

In the structural on characteristic of the SDR terminal, lots of the times is required in the Waveform reconfiguration and it is impossible to maintain session of the application in which it communicated.

That is, the SDR terminal means the Seamless VHO that it is impossible to perform. This kind of a problem limits the application in which it is available in the SDR terminal, especially, the use of the Application in which it is sensitive to a delay like VOIP is impossible. The problem like this lowers the availability of the SDR terminal and it is unable to provide the Seamless service in the Mobile environment.

In order that the problem like this is solved, the SDR terminal predicts Handover an occurrence in advance, the execution procedure of the Waveform Application in which the latency time is very much required is performed in advance, and The SDR terminal is activated to the Dual-Mode terminal. And it is reconfigured to the Single-Mode terminal after Handover for the efficient use of a resource.

2. Related Works

2.1. Software Defined Radio and Software Communication Architecture

The SCA CF is standardized for the application component and provides an open standards interface and the service. The CF was the help in the design of the application component designer through an abstraction, the lower part software and hardware hierarchy.

The SCA CF interface and services divided as follows:

- BAI (Base Application Interface): This application component should provide an interface and must be implemented interface. (Port, LifyCycle, TestableObject, PropertySet, PortSupplier, ResourceFactory)

- FCI (Framework Control Interface): The interface used in the SCA CF inside for the system control, and is an offer or an used interface and the service between CF inside functional elements. (Application, ApplicationFactory, DomainManager, DeviceManager)

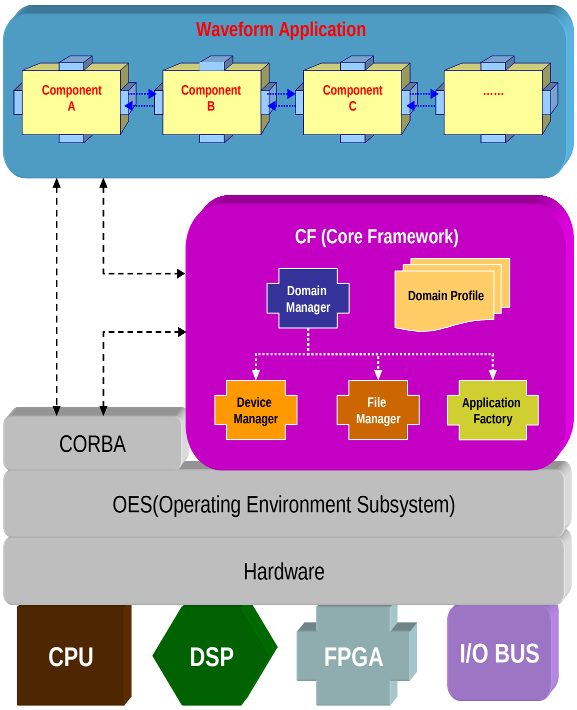

Figure 1. Software Defined Radio Architecture

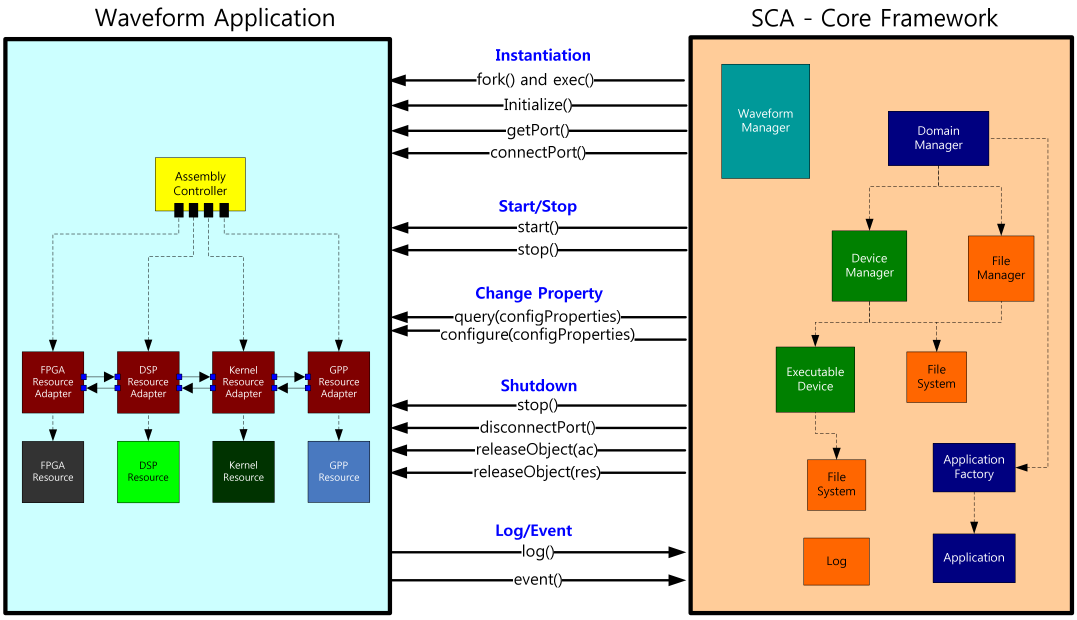

Figure 2. SCA Interface and API for Waveform Application Control

- BDI (Base Device Interfaces): It is the interface in which it provides the management and implementation of the logical device within a domain. (Device, LoadableDevice, ExecutableDevice, AggregateDevice, DeviceManager)

- FSI(Framework Service Interface): The interface used by the external application program like the core framework part inside application, or the download management, and the application component. (File, FileSystem, FileManager, Timer)

- Domain Profile: There is the Software profile for the Device Profile in which we define the hardware attribute of the SDR terminal device and software component definition. This profile was written in XML form.

- The Waveform Application consists of one or more Resources. The Resource interface provides a SCA common API for the control and configuration of a software component for Waveform Application. The application developers can extend these definitions by creating specialized Resource interfaces for the application.

The Waveform Application consists divided as follows.

- Assembly Controller : Assembly Controller for Resource Control

- FPGA Resource : Implement for Baseband, RF

- DSP Resource : Implement for RF and Multimedia Signal Processing

- Kernel Resource : Implement for L1 Driver and L2 MAC

- GPP Resource : Implement for User Interface and L3

Each Resource has an Adapter corresponding to itself. The Assembly Controller mutually works with the Adapter of an individual in order to perform the start, stop and property control about the Resource of the Waveform Application.

Waveform application components are performed by the Executable Device with the fork() and exec(). And they go by Application with Initialize() and are performed. Moreover, the getPort() and connectPort() are used for the port information reference and attach of each component.

The CF can perform the Waveform application component through the start() and stop() interface method of Application with a start and stop.

In an application, the query(), and the configure() interface are used in order to inquire the attribute of the Waveform application component and change.

2.2. Media-Independent Handover Services (IEEE 802.21)

The scope of the IEEE 802.21 standard is to facilitate the handover between IEEE 802 and non-IEEE 802 access networks in a way that is independent from particular access network features.

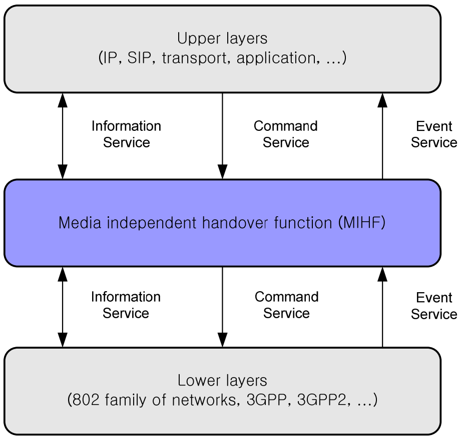

Figure 3. MIH services [3]

The MIHF is located both in the mobile node (MN) and the network node protocol stack and provides three types of services:

- The media-independent event service (MIES)
- The media-independent command service (MICS)
- The media-independent information service (MIIS)

The MIES is responsible for detecting events and reporting them from both local and remote interfaces. This type of service is provided from lower layers to upper layers. Link deterioration and link unavailability are examples of such events reported to higher layers [3].

On the other hand, the MICS offers commands to higher layers to control the lower layers regarding handover. Commands follow a top-down direction as opposed to events. Typical commands are the configuration of network devices and the scanning of available networks [3].

Table 1. MIIS Information elements [2]

Name of information element	Description
IE_NETWORK_TYPE	Link types of the access networks that are available in a given geographical area.
IE_OPERATOR_ID	The operator identifier for the access network/core network.
IE_SERVICE_PROVIDER_ID	Identifier for the service provider.
IE_COUNTRY_CODE	Indicate the country.
IE_ROAMING_PARTNERS	Roaming Partners. Network Operators with which the current network operator has direct roaming agreements.
IE_COST	Cost. Indication of cost for service or network usage.
IE_NETWORK_DATA_RATE	Data Rate. The maximum value of the data rate supported By the link layer of the access network.

Media independent information service (MIIS) provides a framework by which an MIHF, residing in the MN or in the network, discovers and obtain network information within a geographical area to facilitate network selection and handovers. The objective is to acquire a global view of all the heterogeneous networks relevant to the MN in the area to facilitate seamless roaming across these networks. MIIS provides a generic mechanism to allow a service provider and a mobile user to exchange information on different handover candidate access networks. The handover candidate information includes different access technologies such as IEEE 802 networks, 3GPP networks, and 3GPP2 networks [2]. In the SDR terminal, the table 1 is the element in which it uses in order to distinguish between the waveform applications.

3. Problem Definitions

3.1. Vertical Handover Based on Software Communications Architectures

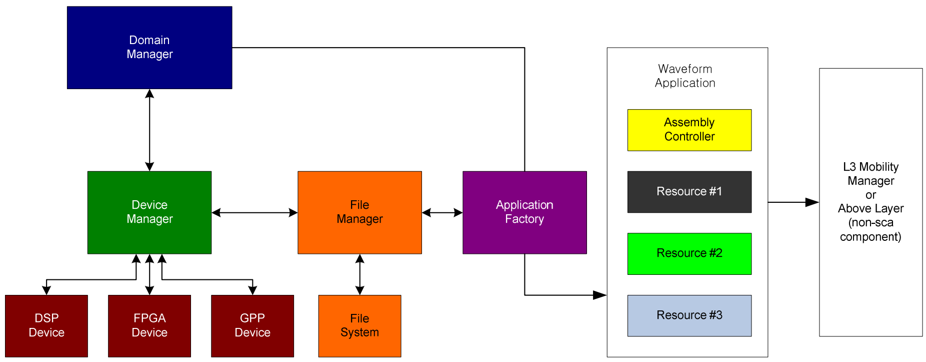

Figure 4. Software Communication Architecture for Single-Mode

After stopping the existing waveform application and carrying out the uninstall procedure, the case of doing Handover by Single-mode executes a new waveform application.

While the installation of the new waveform application in the time when the preexistence waveform applications stops and uninstall is performed, and an execution is completed, a connection the SDR terminal is impossible in a network. In this procedure, the SDR terminal performs the Hard Vertical Handover and a user loses all information of connected session. As to this time, the SDR terminal is the time to certainly need for a reconfiguration and the software performed in FPGA, DSP, GPP is changed in these procedures.

4. Proposed Mechanism (VHO-SCA)

In this section we will show and discuss our proposed scheme the Seamless Vertical Handover in the SDR Terminal, Our scheme is the enhanced SCA Reconfiguration Procedure that Vertical Handover support will be possible. We will discuss in detailed our proposed scheme the VHO-SCA.

4.1. Proposed VHO-SCA

Some new components was added in order to operate with the existing SCA architecture with MIH. The Core Framework was added to the MIH Manager, Waveform Application Manager and Waveform Application Repository. The MIH Manager corresponds to the architecture of MIH User, Waveform Application Repository has the index of Waveform Application and store Waveform Application file. The Waveform Application Manager controls the Domain Manager for reconfiguration of waveform application. All Waveform Application must be implemented MIH Function to support MIH.

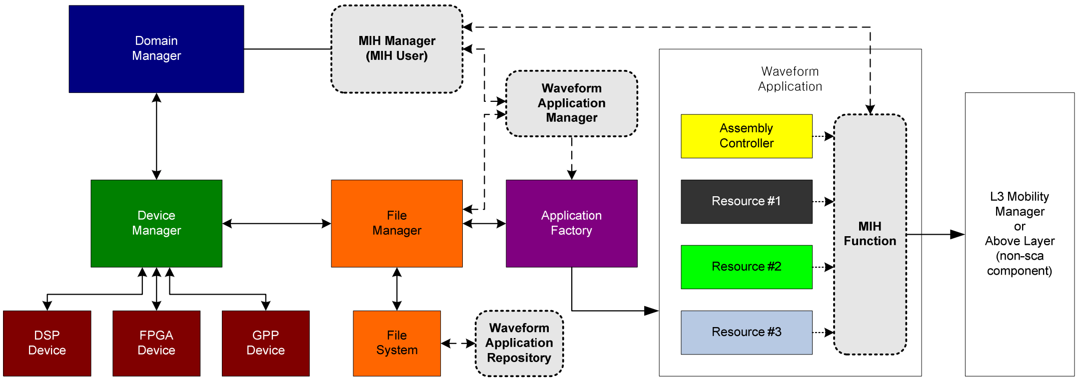

Figure 5. The SCA Architecture for Supporting Vertical Handover

In this section we will show and discuss our proposed scheme the Seamless Vertical Handover in the SDR Terminal, Our scheme is the enhanced SCA Reconfiguration Procedure that Vertical Handover support be possible. We will discuss in detailed our proposed scheme the VHO-SCA.

The MIH Manager received the Access Network Information through the MIIS server of MIHF. The Waveform Application Manager with the corresponding waveform application exists on the Waveform Application Repository to retrieve. If it doesn't exist, it approaches to the Waveform Application Repository Server defined as the Information Element of MIIS and the new Waveform Application file is downloaded. It stores in the Waveform Application Repository.

The MIH Function delivered the information elements of a neighboring through MIIS. The MIIS message in which the MIH Function receives is delivered to the MIH Manager and the IE_NETWORK_TYPE information element of MIIS is delivered to the Waveform Application Manager. The Waveform Application Manager searches for whether the Waveform Application described on IE_NETWORK_TYPE information element exists in the Waveform Application Repository or not. If there is no usable Waveform Application, the corresponding Waveform Application get a transmission of from the Waveform Application Repository Server in which it comes to the Waveform Application Server Specific Information Elements of MIIS and The Waveform Application file in which it receives is stored in Waveform Application Repository. Figure 5-6 show the process where the SDR terminal operates with Multi-Mode for the Seamless VHO. The detail process is as follows.

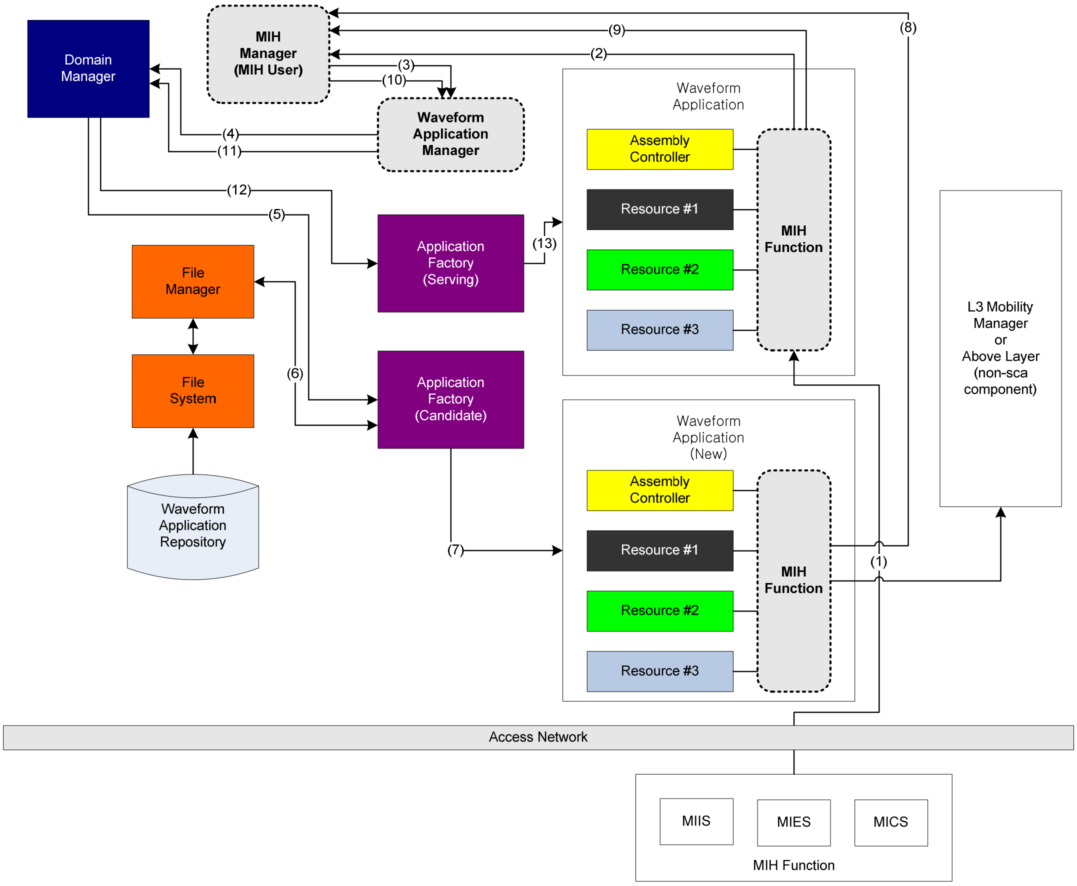

Figure 6. The SCA Architecture for Supporting Vertical Handover

The delivery of the event in which it relates to a handover from MHIF in the waveform application and this event will be forwarded to the MIH Manager. MIH Manager based on information from the MIIS install a new need to select the Waveform Application, the Waveform Application Manager searches for it has the selected the Waveform Application File.

The Waveform Application Manager confirms whether there is the corresponding Waveform Application in the Waveform Application Repository or not, Domain Manager is requested to install the Waveform Application. The Domain Manager produces the Application Factory for being created with the new Waveform Application and the Application Factory creates the Waveform Application. It delivers to the MIH Manager if the MIH Function of the newly created Waveform Application receives the MIH_Link_ Event including MIH_Link_Detected or MIH_Link_Up.

If the MIH Manager determined that handover was the completed, it requests to uninstall the Waveform Application in which it uses in a preexistence to Waveform Application. The Waveform Application Manager requests that it gives the corresponding Waveform Application to the Domain Manager with uninstall. The Domain Manager requests that the Application Factory uninstall the old Waveform

Application. The Application Factory uninstalls Waveform Application and the Domain Manager uninstalls the Serving Application Factory.

4.2. Proposed VHO-SCA with PMIPv6

Figure 7 - 10 show the detailed flow chart in which PMIPv6 and VHO-SCA operate with.

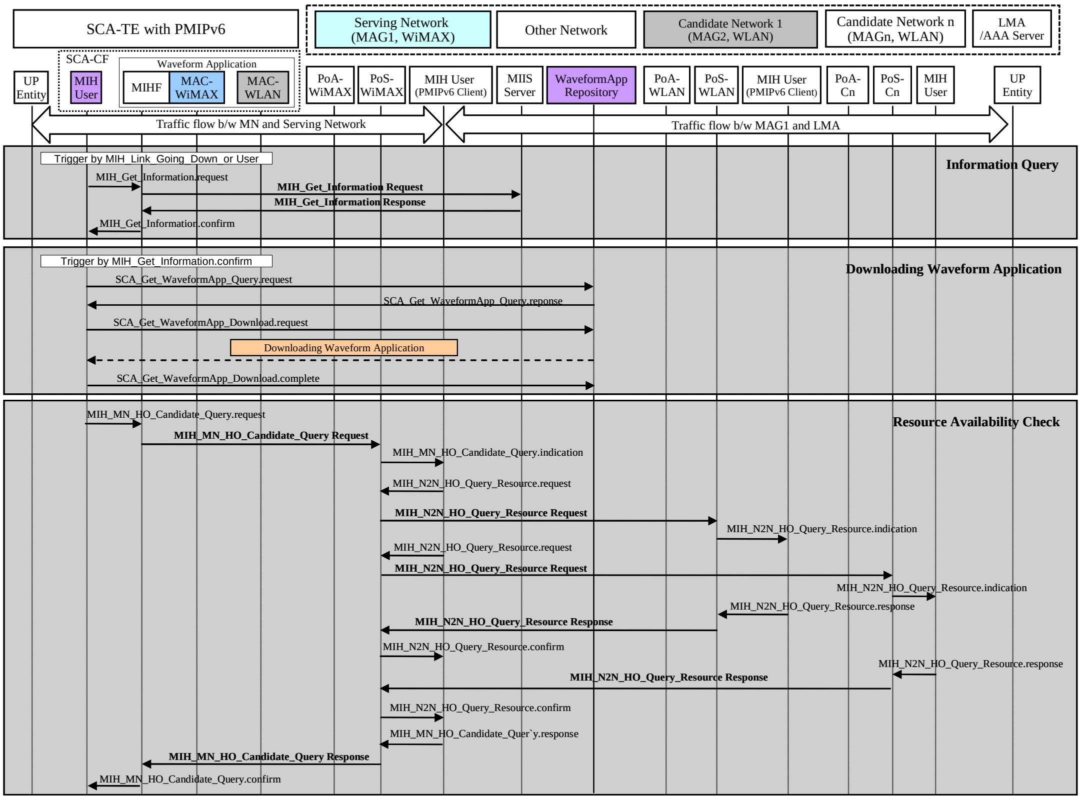

Figure 7.Enhanced Scheme for PMIPv6 Handover Procedure with VHO-SCA

Figure 7 shows a mobile-initiated handover flow chart in which PMIPv6 and VHO-SCA operate with. The handover flow operates as follows:

SDR-TE receives packets through both MAG1 located in the current serving network and LMA. The SDR-TE queries the MIIS server by using the MIH Get Information message to get information about available neighboring networks. This information query can be attempted as soon as the MN attaches to a new serving network or periodically for refreshing the information or manually by a user or trigger by MIES Event.

The MIH User sends the SCA_Get_WaveformApp_Query request messages to the informed the WaveformApp Repository in order to query the availability of the waveform application in which it includes IE_NETWORK_TYPE, IE_OPERATOR_ID in the MIH Get Information message. WaveformApp Repository responds by sending the SCA_Get_WaveformApp_Query response message to the SDR-TE. If need, The

MIH User sends the SCA_Get_WaveformApp_Download request messages to the informed the WaveformApp Repository in order to download waveform application. The MIH User sends SCA_Get_WaveformApp_Download.complete messages to the informed WaveformApp Repository download was completed to the waveform application.

SDR-TE sends the MIH_MN_HO_Candidate_Query request message in which contains requirements for potential candidate networks to the Serving Network PoS for triggering a mobile-initiated handover.

The Serving Network PoS sends the MIH_N2N_HO_Query_Resource request messages to the informed Candidate Network PoSs (can be more than one) in order to query the availability of the resource at the candidate networks. The Candidate Network PoS responds by sending the MIH_N2N_HO_Query_Resource response message to the Serving Network PoS. The Serving Network PoS in turn sends MIH_MN_HO_Candidate_Query response message to the SDR-TE.

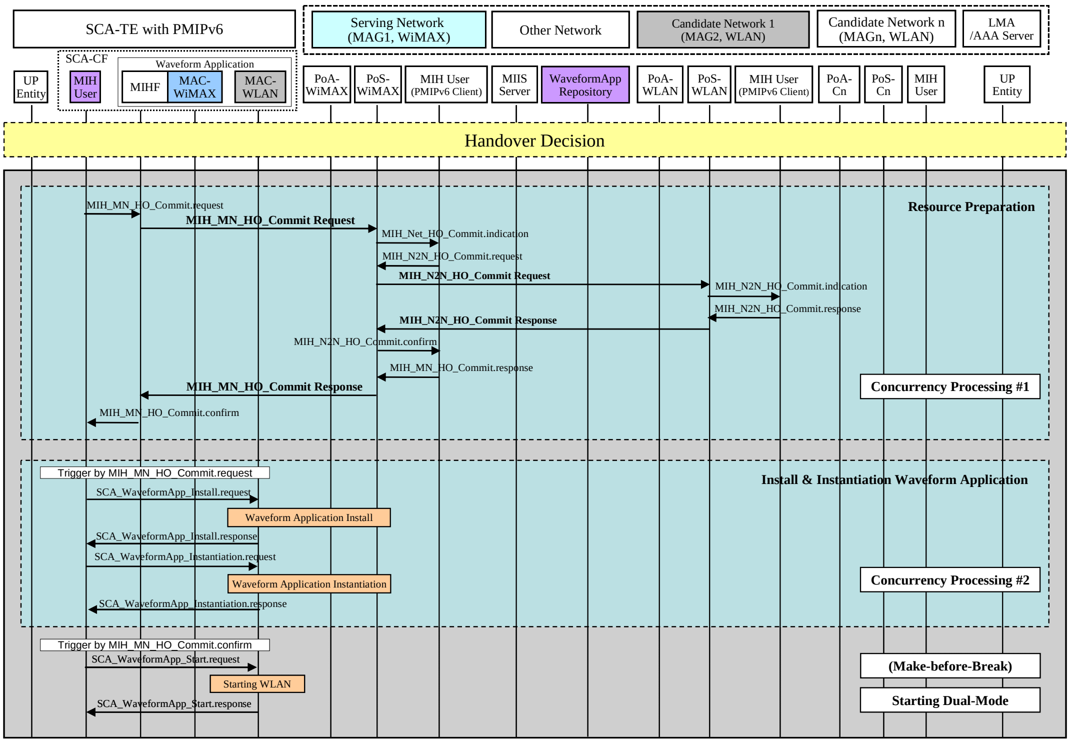

Figure 8. Enhanced Scheme for PMIPv6 Handover Procedure with VHO-SCA

Finally, the SDR-TE decides the handover target based on the result of query about resource availability at the candidate networks [2].

The SDR-TE sends the MIH_MN_HO_Commit request message to notify the Serving Network PoS of the decided target network information. The Serving Network PoS reserves the resource at the target network through MIH_N2N_HO_Commit messages. Upon receiving the MIH_N2N_HO_Commit request message, PMIPv6 client as MIH user in the target PoS queries the incoming SDR-TE's profile to a policy store such as

AAA server. As a result, the Target network PoS obtains the MN's information for PMIP processes in advance [2].

The Target PoS replies to the Serving PoS with the result of the resource preparation by sending MIH_N2N_HO_Commit response message.

The MIH User installs the downloaded waveform application. If there was successfully an installation, the MIH User instantiates the downloaded waveform application.

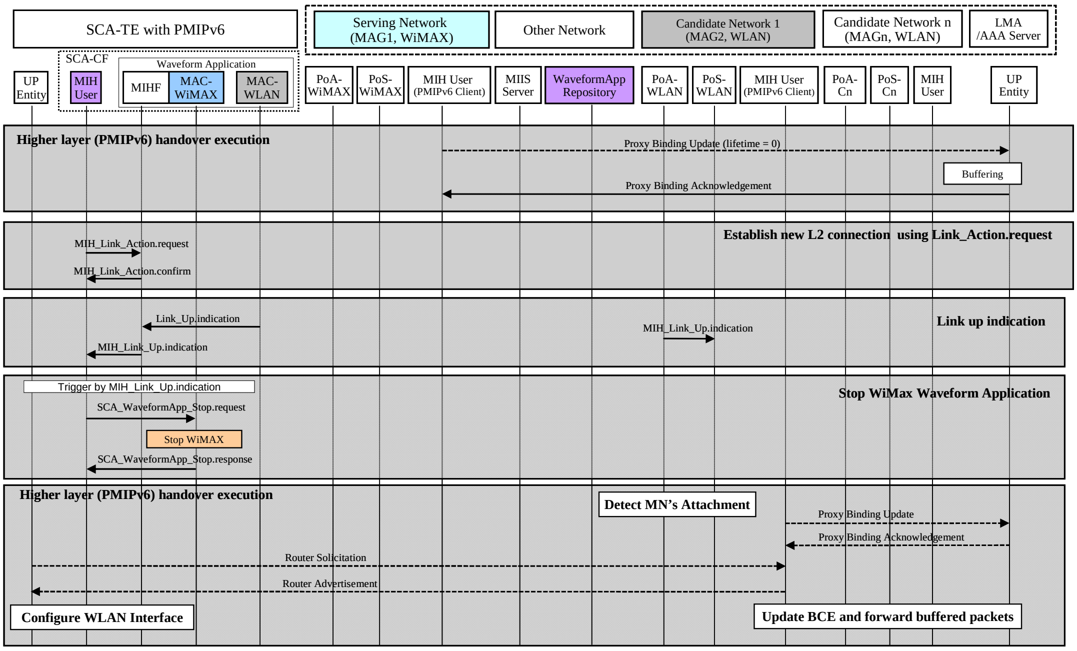

Figure 9. Enhanced Scheme for PMIPv6 Handover Procedure with VHO-SCA

The SDR-TE performs handover to the specified network type and PoA by the MIH_Link_Actions.request primitive. Upon detecting the MN's detachment, the PMIPv6 client in the Serving Network PoS terminates its current binding of the MN via sending Proxy Binding Update with Lifetime set to 0 and requests the LMA to buffer packets destined for the MN [2].

The MIH User sends the SCA_WaveformApp_Start request messages to assembly controller in the WLAN waveform application in order to start WLAN.

Once the SDR-TE establishes the layer 2 connection to the Target Network PoS, the PMIPv6 client as an MIH user in the Target Network PoS registers the current MN's location to the LMA by sending a Proxy Binding Update message. The LMA updates its Binding Cache Entry with the Proxy Binding Update message and then replies with Proxy Binding Acknowledgement message. The LMA also forwards the buffered packets [2].

The MIH User sends the SCA_WaveformApp_Stop request messages to assembly controller in the WiMAX waveform application in order to stop WLAN.

After receiving the Proxy Binding Acknowledgement message, the PMIPv6 client sends a Router Advertisement message to the SDR-TE. The Router Advertisement is constructed with the MN's information obtained from the policy server and LMA. It can be solicited by a Router Solicitation message from the MN or periodically transmitted. SDR-TE configures IP addresses on its interface, which is currently used to connect to the Target Network PoS, with the received Router Advertisement message. Once the PMIPv6 procedures are completed, the SDR-TE receives packets through both MAG2 and LMA [2].

The MIH User sends the SCA_WaveformApp_Unload request messages to the Application Factory in the SCA Core Framework in order to unload WLAN Waveform Application.

After the PMIPv6 execution, the Target Network PoS sends the MIH_N2N_HO_Complete request message to the previous Serving Network PoS. The previous Serving Network PoS responds to the message with an MIH_N2N_HO_Complete response message [2].

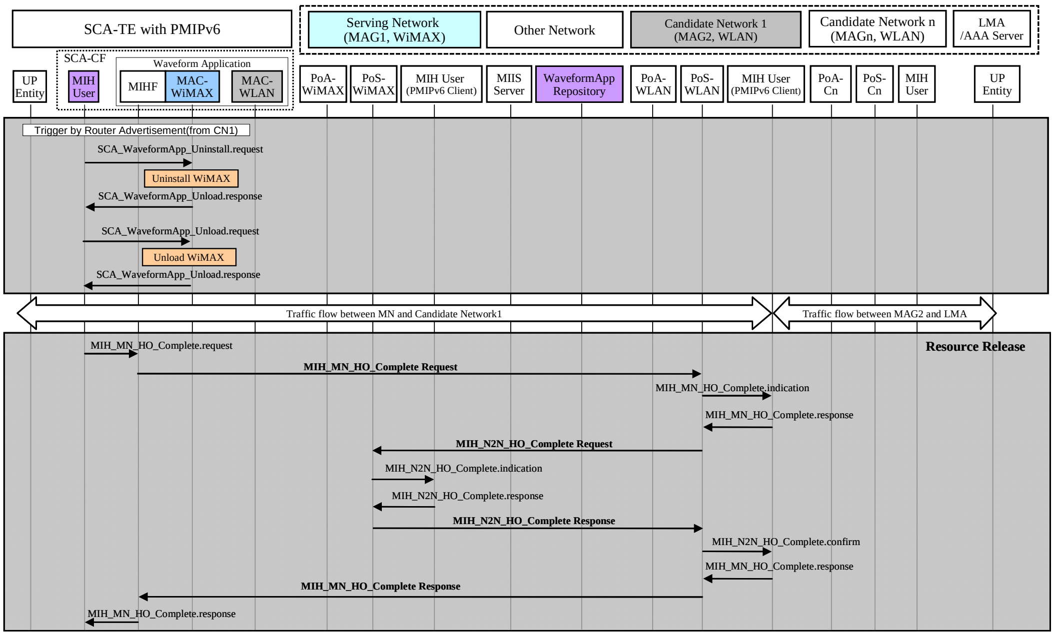

Figure 10. Enhanced Scheme for PMIPv6 Handover Procedure with VHO-SCA

4.3. Using Virtual Interface for PMIPv6 in the SDR Terminal

In the SDR terminal, if the uninstall of the waveform application is performed, the state of the SDR terminal is initialized. This is to prevent from an effect on the new waveform application in which previously the performed waveform application is performed in a next. Therefore, in the Reconfiguration procedure of the SDR terminal, the serving network interface is deleted and the ipv6 address information in which set up by the Router Advertisement disappears.

The virtual network interface is used in order to solve this kind of problem. The network application doesn't directly approach the network interface of the waveform application and it instead of approaches through the virtual network interface. In case the SDR terminal receives the router advertisement from the access network, it doesn't deliver to the network interface of the waveform application and it only delivers to the virtual network interface. However the additional function for processing the ICMP message including neighbor solicitation, neighbor advertisement is needed.

5. Conclusions and Future Works

This paper has described Seamless Vertical Handover Software Communication Architecture (VHO-SCA) as new architecture using IEEE 802.21 MIH. The process for operating the SDR terminal with Dual-Mode was explained in order to support the Seamless Handover and it was seen to IP Mobility could support by applying the SDR terminal to PMIPv6.

References

[1] ETRI Development Report, ``Report on the Development of Middleware Platform for the SDR Terminal,`` ETRI, February 2009.
[2] IEEE Std 802.21, ``IEEE Standard for Local and Metropolitan Area Networks - Media Independent Handover Services,`` IEEE, January 2009.
[3] G. Lampropoulos, A. K. Salkintzis, N. Passas, ``Media-Independent Handover for Seamless Service Provision in Heterogeneous Networks,`` IEEE Communications Magazine, January 2008, pp.64-71.
[4] A.D. L. Oliva et al., ``An Overview Of IEEE 802.21: Mediaindependent Handover Services,`` IEEE Wireless Communications, August 2008, pp.96-103.
[5] V.G. Gupta and D. Johnston, ``A Generalized Model for Link Layer Triggers, `` submission to IEEE 802.21, March 2004.
[6] L. Eastwood, S. Migaldi, Q. Xie, V. Gupta, ``Mobility Using IEEE 802.21 In A Heterogeneous IEEE 802.16/802.11-BASED, IMT-ADVANCED (4G) Network,`` IEEE Wireless Communications, April 2008, pp.26-34.
[7] A. De la Oliva et al., ``IEEE 802.21 Enabled Mobile Terminals for Optimized WLAN/3G Handovers: A Case Study,`` ACM SIGMOBILE Mobile Computing and Communications Review Vol.11, April, 2007, pp.29-40.
[8] Kenichi Taniuchi et al., ``IEEE 802.21: Media Independent Handover: Features, Applicability, and Realization,`` IEEE Communications Magazine, January 2009, pp.112-120.
[9] T. Ali-Yahiya, K. Sethom, G. Pujolle, ``A Case Study: IEEE 802.21 Framework Design for Service Continuity across WLAN and WMAN,`` Wireless and Optical Communications Networks, February 2007.
[10] T. Ali-Yahiya, K. Sethom, G. Pujolle, ``Seamless Continuity of Service across WLAN and WMAN Networks: Challenges and Performance Evaluation,`` IEEE/IFIP International workshop on Broadband Convergence Networks, May 2007.
[11] Joint Tactical Radio Systems, ``Software Communications Architecture (SCA) Specification MSRC-5000SCA V2.2,`` JTRS, November 2001.
[12] Joint Tactical Radio Systems, ``Software Communications Architecture (SCA) V2.2 API Supplement V1.1,`` JTRS, November 2001.
[13] Joint Tactical Radio Systems, ``Software Communications Architecture (SCA) V2.2 Requirements,`` JTRS, December 2002.
[14] J.Bard, V. J. Kovarik, ``Software Defined Radio: The Software Communications Architecture,`` John Wiley \& Sons Publishing, 2007.
[15] OMG (Object Management Group), ``The Common Object Request Broker: Architecture and Specification, Version 3.0,`` OMG, June 2002.

[16] D. Johnson, C. Perkins, and J. Arkko, ``Mobility Support in IPv6,`` RFC 3775, June 2004.
[17] S. Gundavelli, K. Leung, V. Devarapalli, K. Chowdhury, B. Patil, ``Proxy Mobile IPv6,`` IETF RFC-5213, August 2008.
[18] Q.B. Mussabbir, W. Yao, Z. Niu, X. Fu, ``Optimized FMIPv6 Using IEEE 802.21 MIH Services in Vehicular Networks,`` IEEE Transactions on Vehicular Technology,November 2007, pp.3397-3407.
[19] IEEE Std 802.16e, ``IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems,`` IEEE, February 2006.
[20] IEEE Std 802.16g, ``IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems: Management Plane Procedures and Services,`` IEEE, December, 2007.
[21] WiMAX Forum, http://www.wimaxforum.org/
[22] L. Nuaymi, "WiMAX," John Wiley \& Sons, January 2007.
[23] Seamless and Secure Mobility Project, National Institute of Standards and Technology, http://w3.antd.nist.gov/seamlessandsecure.shtml

Authors

Hwan-Souk Yoo received the B.S. and M.S. degree in Computer Science from Chungnam National University, Daejeon, Korea, in 2001 and 2003. He has joined Electronics and Telecommunications Research Institute(ETRI) as a visited assistance researcher between 2001 and 2002. He went on for a Ph.D. program in Computer Science from Chungnam National University, in 2003. He was with SDR Middleware Research Team(ETRI) as a researcher and R&D for SDR Technology, between 2007 and 2009. His current research interests include wireless communication network, software defined radio, SCA, network simulator, IPTV Qos, and inter-domain routing.
His email address is grep@cclab.cnu.ac.kr.

Byungjoo Park received the B.S. degree in electronics engineering from Yonsei University, Seoul, Rep. of Korea in 2002, and the M.S. and Ph.D. degrees (first-class honors) in electrical and computer engineering from University of Florida, Gainesville, USA, in 2004 and 2007, respectively. From June 1, 2007 to February 28, 2009, he was a senior researcher with the IP Network Research Department, KT Network Technology Laboratory, Rep. of Korea. Since March 2, 2009, he has been a Professor in the Department of Multimedia Engineering at Hannam University, Daejeon, Korea. He is a member of the IEEE, IEICE, IEEK, KICS, and KIISE. His primary research interests include theory and application of mobile computing, including protocol design and performance analysis in next generation wireless/mobile networks. He is an honor society member of Tau Beta Pi and Eta Kappa Nu. His email address is vero0625@hotmail.com, bjpark@hnu.kr.

Sang-Ha Kim received the B.S. degree in chemistry from Seoul National University, Seoul, Korea, in 1980, and he received the M.S. and Ph.D. degrees in quantum scattering and computer science from the University of Houston, Houston, TX, in 1984 and 1989, respectively. He was with the Supercomputing Center, SERI, Korean Institute of Science and Technology (KIST) as a senior researcher between 1990 and 1991. He has joined Chungnam National University, Daejeon, Korea, since 1992, where he is a Professor. His current research interests include wireless networks, ad hoc networks, sensor networks, QoS, optical networks, and network analysis. Prof. Kim is a member of ACM, IEEE Communications Society, IEEE Computer Society, KICS, KIPS, etc. His email address is shkim@cnu.ac.kr.