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The Scheme of Vertical Handover Procedure with Care-of-Address Function

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We analyze the possibilities of using the cognitive radio standard IEEE 802.22. Temporarily unoccupied channels can be used for transferring information where 3GPP LTE service becomes impossible. The technology is very actual in sparsely populated areas. The current paper offers a complete vertical handover procedure from 3GPP LTE to the cognitive radio network IEEE 802.22 with the IP address preserved for easy user recognition. The procedure includes the authorization phase, registration, authentication and connection. The proposed procedure includes Care-of-Address Function for saving an IP address, which will be useful for mobile users. The main idea of proposed vertical handover procedure is saving of a temporary IP address. The vertical handover procedure based on entities from 3GPP LTE network and target IEEE 802.22 WRAN network. This procedure consist from 45 signaling messages (requests and responses) between mobile terminal, ANDSF function, Service Gateway and Packet Data Network Gateway, Base Station IEEE 802.22 and some other entities.

Key words and phrases: cognitive radio, customer premise equipment, software-defined radio, IEEE 802.22, WRAN, Care-of-Address.

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1. Introduction

The cognitive radio service allows using temporarily unoccupied channels, so called "white spots", in the range of TV frequencies from 410 MHz to 862 MHz [1, 2]. It is relevant for areas with low population density or in emergencies, when 3G/4G communication cannot be used. There are several radio standards use "white spots" technologies, primarily the IEEE 802.22 standard and the IEEE 802.11af standard. A comparison of these standards shows that IEEE 802.22 standard is more preferable for wireless regional access networks (WRAN). Also IEEE 802.22 standard is the first standard of cognitive radio, which has the status of international standard [3, 4]. We estimated channel access delay in cognitive radio network [5] and a vertical handover delay from Wi-Fi to 3GPP LTE [6]. We never used Care-of-Address (CoA) function with saving temporary IP-address for mobile users. This approach will include CoA function for mobile users vertical handover (VHO) delay.

2. Care-of-Address for mobile users in Inter System VHO

TA model for VHO from 3GPP LTE to a cognitive network IEEE 802.22 with "white-spots for the Wireless Regional Access Network (WRAN) was developed in [7]. Such transition refers to inter system vertical handover and needs for a new IP-address in a target network. Current versions of an IP protocol for mobile users allow to link the "Home Address" and the address of user equipment in the target network.

This temporary address is denoted as the address for the CoA transfer [8, 9]. This solution allows redirecting traffic from the user's home network to the target network using CoA, including with inter-system VHO, which becomes essentially a "seamless handover". The corresponding possibilities are available in mobile versions of the IP protocol, MIPv6 and MIPv4 (Mobile IP version 6 and 4). In this case, inter-system VHO provides macro-mobility at the level of the IP protocol. Such capabilities are provided by the MIPv6 protocol, HMIPv6 (Hierarchical MIPv6 Management protocol), FMIPv6 (Fast Handover for MIPv6). To ensure CoA with inter-system VHO, it is most expedient to use MIPv6. The user device that uses MIPv6 receives information about the Home Agent, the home agent address, and the IPsec protocol parameters through the current service network. To ensure flexibility and prevent disruption of the session, the IKEv2 security protocol extension called MOBIKE (IKEv2 Mobility and Multihoming) protocol is used.

Previously, we did not consider the vertical handover delay at the IP protocol level. For example, the RTT (Round Trip Time), jitter (jitter), and the packet loss ratio was used in [10]. For real-time services and a transfer rate of 3 Mbit/s the RTT is equal 59 ms for the Wi-Fi network and114 ms in the LTE network. In [11] the IP protocol was not considered, studies were conducted only for the physical and channel level. The horizontal handover delay from one to another cell in the IEEE 802.22 network is 150 -180 ms for the mobile users with speed 2 -10 mps for the Media Access Control level without the delay for registration and authentication. In [12] you can see a general scheme for delay formation for different versions of a MIP protocol, but there is no delay analysis for any stage of the horizontal handover. The propose [13] use unanchored IP address to support the streaming services and the corresponding IP session, and the main role belongs to the user equipment. In [14] economic aspects are considered for different market strategies for the wireless access networks development, but without the analysis of the access delay to fixed wireless networks through which off-load traffic is carried out. Thus, the problem of providing CoA function for mobile users is very important and actual, and there is no an analytical model for VHO delay estimating with CoA.

Let the mobile terminal (User Equipment) support a physical connection and an IP session through the 3GPP LTE base station (eNodeB). We consider the case where the mobile terminal uses the IP address received in 3GPP LTE when going to the target IEEE 802.22 network.

The IEEE 802.22 and the ANDSF (Access network discovery service function) have the same functions within the overall model of the process of accessing heterogeneous cognitive network resources, these nodes are treated as a single functional entity, "ANDSF / Spectrum Manager", but each node processes alarm messages for different times. Given the coincidence of the functional assignment of the radio frequency spectrum manager IEEE 802.22 and Access network discovery service function (ANDSF) within the general model of access to heterogeneous cognitive networks resources, these nodes are considered as a single functional entity, "ANDSF/Spectrum Manager", but each node processes signaling messages differently.

3. A VHO Procedure with saving an IP address

The mobile terminal organizes an IP session through the current 3GPP LTE network through the eNodeB, S-GW (Service GateWay) and P-GW (Packet Data Network Gateway). The mobile terminal due to the deterioration of the QoS (Quality of Service) makes inter-system VHO to the target IEEE 802.22 WRAN network. In an IEEE 802.22 network, the mobile terminal (UE) is treated as a CPE (Customer Premises Equipment).

The scheme of intersystem VHO to the target IEEE 802.22 network is presented in Figure 1.

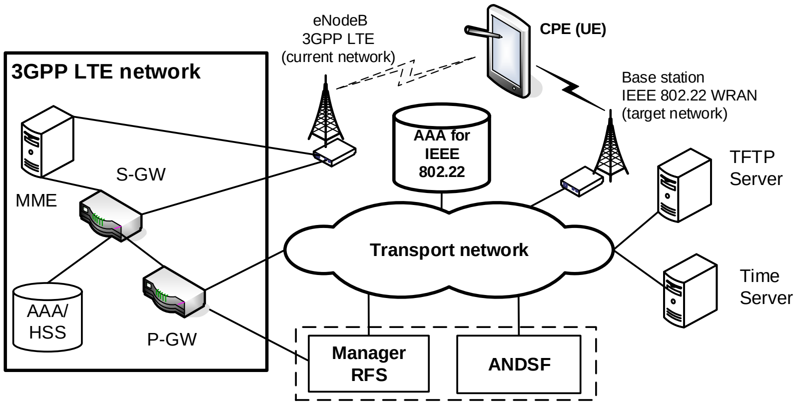

Figure 1. Scheme of intersystem VHO in IEEE 802.22 network

The first phase of vertical handover procedure is shown in Figure 2. The phase shows detecting the IEEE 802.22 network using ANDSF. As a result, the CPE (UE) receives information about the available target networks, including IEEE 802.22.

Request (1) ClientHello is transmitted via IP protocol with the PSK keyset for mutual authentication of CPE and ANDSF and for the organization of the TLS tunnel. A response (2) is sent to the request indicating the safe transfer of the GBA. The request (3) indicates the selected method for loading network information using B-TID and provides a response (4) as the final message for exchanging public keys, after that a secure TLS connection is formed. Request (5) with data on technical capabilities and location of the terminal allows receiving a response (6) indicating the identifiers and radio access technologies (RAT) of the target network.

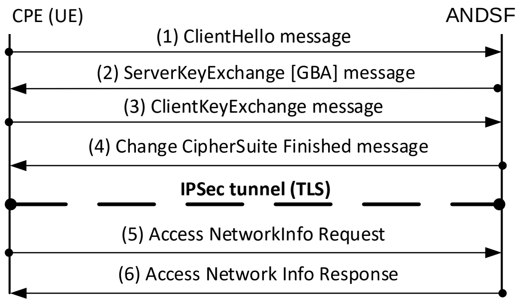

Figure 2. The authorization phase of CPE in inter-system VHO LTE - IEEE 802.22 WRAN

The mobile terminal (CPE, UE) starts connecting and authenticating to the selected network IEEE 802.22 WRAN with saving the current IP address. Figure 3 shows the next phase of registration, authentication and connection to the target network IEEE 802.22 WRAN. The request (7) is about technical characteristics of CPE connecting to the base station 802.22 RNG-REQ (Ranging Request), an the response message (8) RNG-CMD message (Ranging Command) put, indicates the frequency bandwidth for further identifications.

After that, the CPE transmits request for negotiation CBC (CPE Capability Request) property (9) of the IEEE 802.22 network and receives a CBC Response (CPE Capability Response) (10) with the values of the required parameters. For EAP authentication is generated an SCM (11) request, which generates the SCM request (12) to AAA, and then the SCM response (13) from AAA and SCM (14) from BS IEEE 802.22 for successful authentication. SCM Key Request (15) protect the streaming traffic and SCM Key-Reply (16) gives the required Key.

REG request (17) and REG response (18) are responsible for a registration in the IEEE 802.22 WRAN network. After that the mobile terminal (CPE, UE) is connected to the IEEE 802.22 network at the physical and data link layer.

We use Care-of-Address (CoA) function for saving IP address and CPE (UE) use mobile protocol MIPv6. The next phase of VHO scheme with CoA function is shown on Figure 4. CPE transmits IKE_SA_INIT request (19) over the IKEv2 protocol for initialization the Security Association (SA) and receives IKE_SA_INIT response (20) for the secure transfer of the IKE_AUTH request (21) when the CoA procedure begins. The ePDG node broadcasts the IKE_AUTH authorization request (22) and the HSS/AAA node transmits the EAP-Request/AKA challenge (23) for EAP authorization. The response (24) of the IKE_AUTH notifies the CPE of the initial authentication. IKE_AUTH request (25) confirm the authentication by the client and the request (26) redirects towards the HSS/AAA node. The response (27) confirms the final Authentication Answer, which is transmitted as a response (28) to the CPE. CPE transmits a response message IRE_AUTH (29) about the successful procedure through the IKEv2 protocol. P-GW node via a response (30) IKE_AUTH sends to CPE configuration information and IP-address with CoA. The mobile terminal CPE receives information by IKE_AUTH response (31) and the temporary IP address with CoA function, which is the same as the IP address of the terminal on the 3GPP LTE network. The CPE software provides readiness for operation in the IEEE 802.22 network through the IPsec tunnel with CoA support. CPE sends a Binding Update request (32) for registration CoA address in 3GPP LTE network when using DSMIPv6. For supporting an IP address with CoA function an IP-CAN (IP-connectivity access network) Session Modification (33) is sent for all active sessions on the IEEE 802.22 network. The Acknowledge IP-CAN Session Modification response (34) confirms IP session modification, and Binding Acknowledgment response (35) updates the CoA binding for CPE.

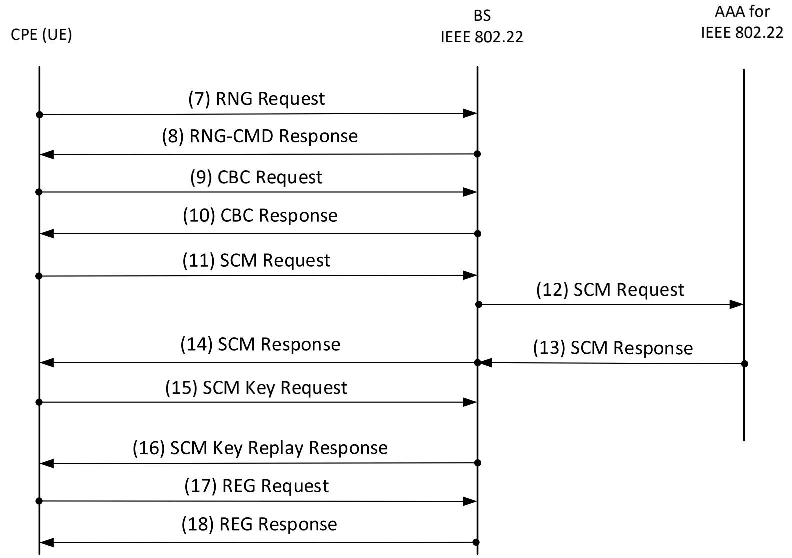

Figure 3. Registration, authentication and connection to the target network IEEE 802.22 WRAN

The request for IP address with CoA registration (36) is sent to the BS of IEEE 802.22, after which an IP session establishment with CoA through the IPsec tunnel is complete for the CPE. As a result, the data packets will be safely routed to the IP address previously assigned in the 3GPP LTE network.

The last phase of VHO procedure refers to the target IEEE 802.22 network, see Figure 5.

The request Time and Date (37) sets the exact current time and date to the CPE for service delivery events registration. The Current Time and Date response (38) confirms the current time and date on CPE. The Read request (39) sent a configuration file and informs about session initiation. CPE receives by the Data response (40) a configuration file for the streaming services organization. TFTP-CPLT (Config File TFTP Complete Message) request (41) notifies CPE and confirmation of the successful configuration upgrade is in TFTP response (42). Mobile terminal CPE is ready to session initiation in the IEEE 802.22 network, an IP address is already assigned. The Dynamic Service Addition (DSA) request (43) contains technical data, and DSA response (44) includes the dynamic addition of the streaming services, as confirmed by the DSA-ACK response (45). After this procedure the mobile terminal CPE can provide communication services including streaming services through the IEEE 802.22 network with an IP address from the 3GPP LTE network, which provides IP mobility and continuity of providing streaming services.

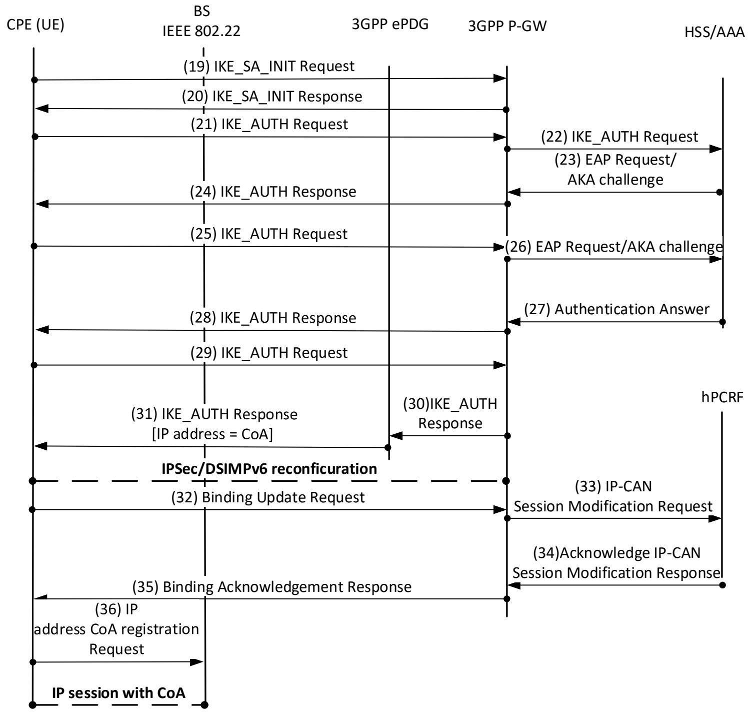

Figure 4. CoA in inter-system VHO in IEEE 802.22 WRAN network

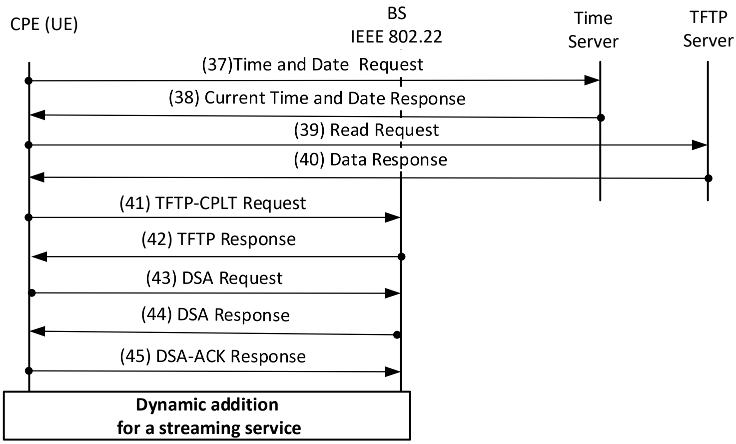

Figure 5. Streaming traffic transmission with CoA to IEEE 802.22 WRAN network

4. Conclusions

As further research we plan to analyze such parameters as mean value or quantile of VHO delay could be found using the data from papaers [4, 15–17]. We will apply the approaches [18, 19] for analysis of new procedure with Care-of-Address function. The proposed procedure starts from LTE, and LTE networks are the 5th generation networks with variety of technologies including radio technologies for wireless communication [20–22]. For such networks, new quality indicators, such as interference [23, 24] affecting signal power and spectral efficiency, as well as traditional indicators, i.e. delays, are analyzed. Sometimes, to optimize the functioning of the system, it is necessary to use special control mechanisms, for example, hysteresis control [25–28]. Another direction of our reserch is using the approaches from cluster method [29] or multidimensional information systems [30].

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