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# An Overview of VHO Security vs. VHO Non-Security in Mobile Networks: Approaches

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***Abstract:*** *The broadband network connections via Vertical Handover (VHO) becomes more ubiquitous day by day which in turn motivates the Mobile Users (MUs) to utilize this feature in accomplishing most of their businesses in the different life aspects. The VHO is taken place based on three main things: MU's preferences (e.g., cost and security), network (e.g., latency and coverage) and terminal (e.g., battery and velocity). This paper focuses on the security as one of the most crucial factors in VHO; therefore, it presents an overview of VHO security approaches against VHO non- security approaches for which their characteristics are discussed.*

***Keywords:*** *Vertical Handover Security, Vertical Handover Non-Security, Wireless Networks, Heterogeneous Networks*

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## I. Introduction

The rapid evolutions in broadband wireless technologies and the growing Mobile Users' demand (MUs) for communication services anywhere, anytime are driving an evolution toward the seamless integration between different Radio Access Technology (RATs) in heterogeneous wireless technologies to provide the best connected services to the MU constantly [1]. Therefore, "globally, business mobile traffic will grow 6.8-fold from 2015 to 2020 and there will be 12 billion mobile connected devices by 2020" [2].

The benefits of heterogeneous wireless technologies are many and varied. These include: flexibility, reducing cost, simplifying the operation and maintenance, rapid deployment of services and applications, new services, high data transmission, customization, support multimedia services at lower cost of transmission, the mobility of the sessions and the possibility to transfer the context [1].

The growing demand for services (e.g., web browsing, file downloading and e-mail) from MUs anywhere, anytime is on the increase regardless of the technological constraints which are associated with different types of RATs such as UMTS, WiMAX and LTE, besides, there is no single RAT is able to satisfy the requirements for all different wireless communications scenarios. Therefore, the telecommunication industry experts are required to develop an interoperability strategy for new mobile wireless systems which can satisfy MUs' demands of telecommunication systems [3].

Although VHO performance is measured by different factors such as latency, packet loss, cost signaling, connection failure and security, we focus on the security as one of the most crucial factors in VHO which has not been considered thoroughly in the previous works. Therefore, this paper presents an overview of VHO security approaches against VHO non- security approaches for which their characteristics are discussed.

The rest of the paper is organized as follows: In section II, security background on heterogeneous wireless technologies is presented. In section III, classifications for VHO approaches are presented. In section IV, a comparison for VHO security approaches against VHO non-security approaches are presented, and finally, section V concludes the paper.

## II. Security Background on Heterogeneous Wireless Technologies

In this section, security background information on heterogeneous wireless technologies is presented, as shown in Table 1:

- 2G: GSM
- 3G: UMTS
- 4G: WiMAX and LTE
- 5 G
- Wi-Fi

**Table 1**. Security comparison of wireless technologies

| Descending Order | Radio Access Technology (RAT) | Generation | Security |
|---|---|---|---|
| 1 | 5G | Fifth | Higher |
| 2 | LTE | Fourth | High |
| 3 | UMTS | Third | Less High |
| 4 | WiMAX | Fourth | Medium |
| 5 | GSM | Second | Medium |
| 6 | Wi-Fi | - | Low |

### 1.1 GSM

GSM is a 2G mobile system which is the first one to specify digital modulation and network level architectures and services [4]. The GSM system mainly is built up of three parts: Network and Switching Subsystem (NSS), Basic Station Subsystem (BSS) and Operation Support Subsystem (OSS) [4]. The NSS includes the equipment and functions related to end-to-end calls, management of subscribers, switching and communicating with other networks such as Integrated Services Digital Network (ISDN) and Public Switched Telephone Network (PSTN) [4].

The NSS includes the following units: Mobile-Station Switching Center (MSC), Home Location Register (HLR), Visitor Location Register (VLR), Authentication Unit Center (AUC) and Equipment Identity Register (EIR) [4]. The HLR is a centralized database that contains subscriber information and location information of all the users residing in the area of MSC [4]. The VLR is a database of all roaming mobiles in the area of MSC but not residing there [4]. The AUC is a database that provides HLR and VLR with authentication parameters and encryption keys required for security purposes [4].

### 1.2 UMTS

The 2G systems like GSM were originally designed for efficient delivery of voice services. The 3G systems like UMTS were on the contrary, it was designed from the beginning for mobile voice and data users [5].

The UMTS security builds on the security of GSM, inheriting the proven GSM security features where it improves on GSM in many ways, including security [6]. The UMTS improved security features come from five security keys [6, 7]:

- Network access security provides secure access to users to 3G services. It is designed to protect attacks on the radio access link.
- Network domain security features take care of security in the core network and protect a network against attacked from the wired interface.
- User domain security features consist of mechanisms that enable secure access to MUs.
- Application domain security features enable the secure exchange of messages between the user and provider domains.
- Visibility and configurability security allow for the configuration of security features by the user on the device.

### 1.3 Wi-Fi

The Wi-Fi (IEEE 802.11) is wireless networks designed to provide broadband for Wireless Local Area Network (WLAN) where the MUs use the mobile devices (e.g., mobiles and laptops) to access the internet in small geographic area such as university's buildings, airports and railway stations. The 3GPP standard differentiates two types of Wi-Fi access technology [8]:

- Untrusted: introduced in the early stages of Wi-Fi specification in 3GPP Release 6 (2005). Untrusted access includes any type of Wi-Fi access that either is not under control of the operator (e.g., public open hotspot, subscriber's home WLAN or that does not provide sufficient security (e.g., authentication and encryption).
- Trusted: trusted access generally refers to operator-built Wi-Fi access with over the air encryption and a secure authentication method.

### 1.4 4G

#### 1.4.1 WiMAX

The WiMAX (IEEE 802.16) is a telecommunication system designed to provide high speed broadband wireless access which is a probable replacement candidate for cellular wireless networks (e.g., GSM) or can be used as an overlay to enhance capacity [9].

The WiMAX network consists of two main blocks: Access Services Network (ASN) and Connectivity Services Network (CSN) [10]. The ASN comprises of Base Station (BS) and ASN Gateway (ASNGW) which are connected over an IP infrastructure [10]. The ASNGW helps in service security anchoring, traffic accounting and mobility support for Mobile Station (MS) where MIP Home Agent (HA) in CSN enables global mobility [10].

### 1.4.2 LTE

The 3GPP's LTE standard evolved from the high speed packet access cellular standards. LTE is a telecommunication mobile system designed to provide higher data rate, higher throughput and lower air-interface latency compared with 2G and 3G systems [11]. The Mobility Management Entity (MME) is the main control node for LTE which is responsible to manage MU identity as well as handling mobility and security authentication [11].

### 1.5 5G

The 5G is defined as upcoming mobile system beyond 4G (B4G) which provides substantial features compared to the current mobile systems [12, 13]:

- Better coverage area.
- Higher data rate (around 1Gbps).
- Lower battery consumption.
- Higher security.
- Better spectral efficiency and Energy efficiency.
- Availability of Artificial Intelligence inspired applications.
- Not harmful for human health.
- Economic services due to low deployment cost.

## III. Classifications for VHO Approaches

This section presents VHO approaches proposed in the literature and classifies them into two categories: VHO security based category and VHO non-security based category for which their characteristics are discussed, as shown in Table 2.

**Table 2**. Classifications for VHO approaches

| Category | VHO Performance Factors |
|---|---|
| VHO non-Security Based Category | Latency, Packet loss, Signaling cost, Connection failure, Throughput, Battery life, Cost, etc. |
| VHO Security Based Category | Security |

### A. VHO non-Security Based Category

In this category, plenty of VHO non-security approaches have been proposed in the literature. In [14], [15] and [16], seventeen, fifteen and ninety VHO approaches have been surveyed, respectively. Also, in [17] a performance evaluation for a VHO approach has recently considered signaling cost. It has been noticed in [14-17] that the VHO approaches ignored the security factor in designing, whereas they confined on the rest factors of VHO performance such as latency, packet loss, signaling cost, connection failure, throughput, battery life and cost.

### B. VHO Security Based Category

The security is one of the most crucial factors in VHO where every single RAT has its own security levels which oblige a MU to comply with them during VHO [16]. In [16] there are nine approaches which have been surveyed about VHO security based category.

## IV. Comparison for VHO Security Based Category Vs. VHO non-security Based Category

Section III has presented two categories of VHO approaches: VHO security based category and VHO non-security based category for which their characteristics have been discussed.

Although the VHO requires enhanced security from malicious attackers (such as eavesdropping, registration hijacking, session tear-down and Denial of Service (DoS)) [16] in order to securely keep ongoing session, the VHO non-security based category obviously takes a large portion of previous works (93%) compared with VHO security based category (7%), as shown in Fig1.

Therefore, it would be preferable to design and develop scenarios taking into account VHO security based category in order to protect VHO from malicious attackers who hardly strive to exploit this process for achieving their goals.

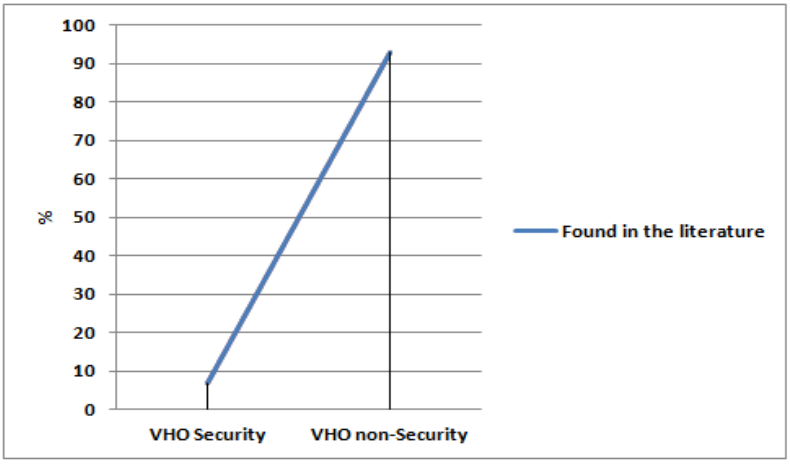


**Figure 1**. VHO security based category vs. VHO non-security based category

## V. Conclusion

This paper has presented an overview of VHO security approaches against VHO non-security approaches for which their characteristics have been discussed. It has been noticed that the VHO non-security based category obviously takes a large portion of previous works (93%) compared with VHO security based category (7%). It is therefore highly recommended that the VHO security based category should be an active area of research compared with VHO non-security based category which has obviously succeeded in presenting and evaluating plenty of VHO approaches.

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