Proposed IP Header Option for New Open Handover Information Transfer Protocol

Malak Z. Habeib, Hussein A. Elsayed, *Member, IEEE*, Salwa H. Elramly , *Senior Member, IEEE,* and Magdy M. Ibrahim, *Senior Member, IEEE.*

***Abstract*—One of the most important requirements of the next generation mobile networks is to guarantee convergence among all of the current wireless networks. So we propose an open layer that supports the handover functionalities across different wireless access networks. In this paper we focus on how to exchange the handover information among any wireless network. Handover depends not only on the user mobility but also on many other parameters that not related to the user mobility. The network cost, battery live time, network load and other factors are examples for the non-mobility handover causes. Considering all handover conditions is a big challenge for the design and implementation of this proposed layer. This paper presents a proof of concept and logical visibility of using the IP header for exchanging the handover information and discusses its importance for next generation mobile networks.**

***Index Terms*—Handover, Heterogeneous, IP Protocol, Mobility, Option IP header, Wireless.**

I. Introduction

THE currently used mobile terminals support a wide range of network access technologies; whereas the mobile terminal vendors compete together for how to add new technology interface with low cost. Multimode wireless terminals [1] are devices that support multiple radio access technologies and allow reception of data over multiple system bearers with different characteristics. This implies the necessity of integration among personal, local, metropolitan and cellular wireless networks [2]. Next generation wireless systems typically constitute different types of access technologies [3]. The heterogeneity that will characterize future wireless systems implies the development of intelligent and efficient handover management mechanisms that can provide seamless roaming capability to the end-users moving between several different access networks. This type of handoff is called Vertical Handover (VHO) because it is happened among different wireless access technologies; this is different than Horizontal Handover (HHO) in which the handover only occurs inside a specific wireless access technology. Now, the most important question is that, how can we prefer one wireless access technology to another and guarantee seamless VHO between different wireless technologies or even in HHO in the same specific wireless network. We alternatively will use the term handover and handoff with the same meaning in our literature.

The vertical or horizontal handover process, in general requires the following three functionalities: network discovery (probing) and measurements, handover decision and involved decision criteria, handover execution by link layer reestablishment, and, if necessary, higher layer procedures [4]. In other words a complete handover protocol that guarantees full mobility management consists of the following main three handover phases as depicts from Fig. 1:

- Phase (1) network discovery and handover triggering measurement phase
- Phase (2) handover decision phase
- Phase (3) handover execution phase

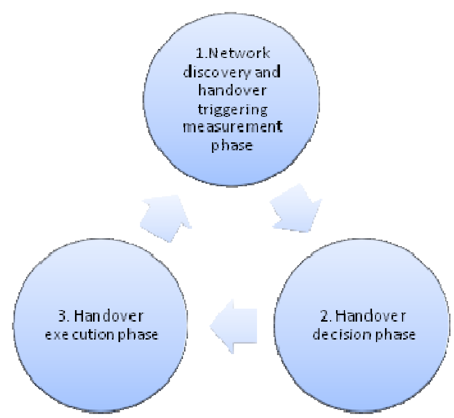

Figure 1. Three handover phases.

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Malak Z. Habeib is with the Electronics and Communication Engineering department, Faculty of Engineering, University of Ain Shams. 1, El Sarayat street Abbassia, Cairo, Egypt (phone: 20-100030179; e-mail: malakojc@yahoo.com).

Hussein A. Elsayed, is with the Electronics and Communication Engineering department, Faculty of Engineering, University of Ain Shams. 1, El Sarayat street Abbassia, Cairo, Egypt (e-mail: helsayed2003@hotmail.com).

Salwa H. Elramly is with the Electronics and Communication Engineering department, Faculty of Engineering, University of Ain Shams. 1, El Sarayat street Abbassia, Cairo, Egypt (e-mail: salwa_elramly@eng.asu.edu.eg).

Magdy M. Ibrahim is with the Electronics and Communication Engineering department, Faculty of Engineering, University of Ain Shams. 1, El Sarayat street Abbassia, Cairo, Egypt (e-mail: magdy_ibrahim@yahoo.com).

Many researchers were focus on the handover execution phase by implementing vertical handover protocols. On the level of network layer Mobile Internet Protocol (MIP) [5] is a typical mobility enabling protocol for the global Internet. Nowadays, numerous studies have focused on the mobility supported Session Initiation Protocol (SIP) [6], which is considered as one of the main approaches for mobility management at the application layer. The Mobility application layer using SIP [7] describes how SIP can provide terminal, personal, session and service mobility. It also describes when MIP should be recommended for terminal mobility. The mobility support at the application layer for real time communication is proposed using SIP [8]. Multilayer mobility management for All IP Networks uses pure SIP versus Hybrid SIP and MIP [9]–[10] evaluates the protocols ability to handle real time sessions. Through evaluation they show the SIP superiority in real time situations whereas MIP is preferred in non-real time situations. The study investigates possibilities of combining the MIP and SIP protocols into a hybrid solution.

A conceptual logic for a complete handover protocol is introduced in [11]. For all the transmission nodes between the source and the destination they calculate the shortest path based on, coverage area, signal strength, power retention, link quality, bandwidth capacity and quality of service with the neighbor to select the network. Their proposed scheme lacks of the modular architecture moreover they suppose the presence of network manger which is practically difficult to implement. As well as it is not open for all existing handover protocols. IEEE802.21 is also requiring a network server that is responsible for collecting handover required information. Whereas our proposed protocol is a distributed approach not centralized so there is no need for the network manger. This is easy feasible using the IP header which takes the functionality of the network manager but in distributed fashion.

Unified mobility management architecture for interworked heterogeneous mobile networks is introduced by Kumudu [12] in which the execution phase of vertical handover protocols is implemented using the integration between SIP and IP Multimedia Subsystem (IMS), however they proposed a manual handover triggering as there is no handover measurement or decision phases are implemented in their approach.

In [13] Youngkyu and Sunghyun succeeded to introduce a good mathematical model for energy efficient WLAN scanning however they didn’t study how to report this information between both WLAN and WiMAX networks. The evaluation study of Yang [14] verifies the usability and validity of their hybrid multiple criteria decision making algorithm that proposed network selection method, but their algorithm focus only on the decision making phase.

In [15] they try to collect state information from the core and access networks efficiently with their flexible Generic Metering Infrastructure (GMI) but they assume the existing of Metering Measurement and Collection Interface (MMCI) which requires a separate signaling scheme that is not easy for practical implementation and considered as a costly solution.

In this paper [16] they proposed a new realistic approach for vertical handover between WiMAX and a WiFi networks. In their scheme, they combine data rate and channel occupancy in order to fairly balance users among the two networks. However they didn’t consider metrics such as quality of service or vehicular speed in their study. As well as they didn’t introduce clear mechanism for exchanging the handover metrics between the networks elements.

Lee et al. [17] proposed a generalized vertical handover decision algorithm that optimizes handover performance by using a combined cost function involving the battery lifetime of the mobile nodes and load balancing over access points and base stations. Also they ignore how to report the battery based handover information. George et al. [18] introduce in their paper, a network based approach for access and interface selection in the context of resource management in heterogeneous wireless environments UMTS, WLAN and DVBT. They interested in designing the decision criteria by trying optimizing predefined cost function while they left the metrics and parameters criteria out of their study scope.

To address all of these needs we introduce the concept of open IP independent layer. This layer not depends on any specific protocol but it can be tailored on any protocol if needed, so it is an open architecture.

The purpose of this paper is to put a conceptual proof for handover information exchange between different network entities. In order to support total mobility management, including interface management, handover decision, and execution. The rest of the paper is organized as follows. Section II describes the main reasons behind why we are interested in IP protocol to transfer the handover information among different network nodes whereas the detailed handover information fields are covered in section III. In section IV we introduce a case study and conceptual proof for our proposed protocol. Finally, section I introduces both paper conclusion and future work.

II. IP Protocol as a Base of our Work

The IP protocol is one of the dominate technologies that is used for the Next Generation Network (NGN). In other words all the NGNs either wireless or not is based on the IP network and IP protocol as their transmission medium. Evolution of all network services based on All IP network is needed for more converged services. All IP technology networking and IP multimedia services are the major trends in the wired and wireless network.

The general idea behind NGN is that one network transports all information and services (voice, data, and all sorts of media such as video) by encapsulating these into packets, like it is on the Internet. NGNs are commonly built around the Internet Protocol, and therefore the term all IP is also sometimes used to describe the transformation toward NGN.

An all IP based 4G wireless network has intrinsic advantages over its predecessors. For starters, IP is compatible with, and independent of, the actual radio access technology. IP tolerates a variety of radio technologies. It lets us design a core network that gives a complete flexibility toward any wireless access network. It may be a core network provider which supports many different access technologies, IEEE 802.11, WiMAX, WCDMA, and some that we haven't even invented yet. All IP network's technology tolerance means unlimited innovation in all direction. The core IP network can evolve independently from the access network. That's the key for using all IP. Open systems IP wireless environment would probably further reduce costs for service providers. Wireless service providers would no longer be bound by single-system vendors of proprietary equipment. Last but not least, an all IP wireless core network would enable services that are sufficiently varied for consumers.

Due to all the above advantages, we are interested in selecting the IP protocol to transport the handover information. Our idea is to use the IP header itself instead of using a new protocol packet format, to transfer all handover needed information. This is simply done by using a new option IP header fields which will be dedicated for handover and mobility purposes.

III. Handover Option IP Header Fields Details and Description

A. IPv4 Packet Header Summary

The IP uses a datagram service to transfer packets of data between end systems using routers. The IPv4 packet header consists of 20 bytes. An option exists within the header that allows further optional bytes to be added, but this is not normally used.

The IP header consists of basic and option parts. The basic portion consists of fields such as version, header length, Type of Service (ToS), control Flags, Time to Live (TTL), protocol field, source and destination Addresses.

Our proposed work mainly based on the option IP part so that we will devote it wide space to discuss. The option field is not normally used; it may be added or not according to the need. It must be implemented by all IP modules (host and gateways). Optional field doesn't mean option field implementation but it means that its transmission in any particular datagram is optional. In some environments the security option may be required in all datagrams. The option field is variable in length so that it may be zero or more octets. There are two format types of an option header:

1. A single octet of option type.
2. An option type octet, an option length octet, and the actual option data octets.

The option length octet counts the option type octet and the option length octet as well as the option data octets. The option type octet is viewed as having 3 fields:

1 bit copied flag,
2 bits option class,
5 bits option number.

The copied flag indicates that this option is copied into all fragments on fragmentation.

0 = not copied
1 = copied

The option classes are:

0 = control
1 = reserved for future use
2 = debugging and measurement
3 = also reserved for future use

B. The Handover Field (HF)

The option binary number '11111' is not used for any purpose, so that we assign this option field to indicate the handover related information that carried directly in the IP packet header. Of course this is option field, we can use it or not anytime we want. Also we can transfer the handover information whenever we need, without any effect or interrupt to the current service sessions. Moreover this information can be exchanged as soon as it generated. This means we will have a very low delay for taking the handover decision from the information transfer point of view.

C. Handover Version Indicator (HVI)

The length of this field is two bits. As we use a draft version for our work we should consider other versions that may be come in the future. This field consists of two bits this means we can have up to four versions. The draft version will take the value of 00. The Handover Version Indicator is presented in Table I.

TABLE I: HANDOVER VERSION INDICATOR

Value	Description
00	Draft version (version one)
01	Future use
10	Future use
11	Future use

D. Vertical or Horizontal Handover Flag (VHF)

The purpose of this 1 bit flag is to determine whether the associated handover information carried in the IP packet belongs to horizontal or vertical handover. If the value of this flag equals to one this means we have vertical handover scenario otherwise this means we interested in exchange horizontal handover information. Using this flag confirms the possibility of the proposed protocol to be open; this means it can be used to deal with either vertical or horizontal handover scenarios.

E. Complete Information Flag (CIF)

Complete information flag consists of 1 bit. The function of this flag is to give an indication whether the current packet has complete information that is sufficient for taking the handover decision or not.

F. *Mapping Classes (MC)*

The length of this field is two bits and it will be used to give a chance for extended future work. To give a chance to organize and distinguish the information related to each handover phase, we introduce the concept of the mapping field. Maybe this mapping is used for other future studies. For example researchers may use them for mobility or any other purposes.

We can categorize four mapping classes as depicted from table II. We will usually use Class '00' as the main mapping class. The description and organization of these classes can be taken as a future research study. For example class 01 may be used for exchanging information related to handover metrics whereas class 01 used for transferring the handover messages itself among different network nodes. In other words class 00 may be used for phase 1 handover and 01 used for phase2 whereas phase 3 can be indicated by using mapping class 10.

TABLE II: MAPPING CLASSES.

Value	Description
00	Mapping number 1
01	Mapping number 2
10	Mapping number 3
11	Mapping number 4

G. *Mapping Flag (MAF)*

Mapping flag consists of 1 bit. This flag is used to determine if we have mapping class field or not. In other words the presence of the mapping class is depending on the value of this flag. If this flag set by 0 this means we have no mapping class otherwise we set this flag by 1 to indicate our desire to use mapping class. This flag is used to state whether we have many maps capability or not. In the beginning of our research as well as for simplicity we will not use the mapping concept here. In this case we should set this mapping flag to equal '0' value.

H. *Variable or Fixed Option Length Flag (VFL)*

This one bit flag is designed to indicate if the handover option IP field length is fixed or variable. In case its length is variable we should put another field that indicates to the length current value. If this flag equals to zero this means that the handover option field length should be constant and the length in this case equals to a fixed '98' bits. In case we use a fixed length there is no use to put a length field, because it will be implicitly known. If a fixed length is our choice we will have two cases. Either we find the information size smaller than '98' bits or it exceeds '98' bits. In the first situation we will complete the '97' bits by adding padding bits whereas in the second case we will exchange the handover information in consecutive packets. The rule of adding the padding bits is the same as the rule that will be followed in part U.

I. *Handover Counter (HC)*

This field consists of four bits which used for exchanging the number of handover counts among different network elements, for a certain user or a specific session. Four bits means we have maximum up to 16 handover attempts horizontal or vertical. By using vertical or horizontal handover flag we can know if this counter used for vertical handover or horizontal handover. In case the number of handover attempts exceeds the counter limit, we can simply use the same upper limit of this counter. Note that, the main purpose of this counter is to check if the number of handover attempts exceeds a certain threshold or not. This means that we don't care about how much is the counter value higher than the threshold. In both cases we compare with a threshold to check if the number of handover attempts is extremely high or not.

By this way we are able to count the number of vertical or horizontal handover actions for a specific user or for a certain session. This information is very useful when we want to take a handover decision and of course this enhances the handover performance. For example violation of this counter threshold may indicate that, the user subject to a ping pong phenomena.

For example, a specific user who has a vertical or horizontal handover flag equals to '0' means that we have a user who has a horizontal handover attempt. Then we will check the handover counter, suppose that we found the counter value equals to '5'. In this case we infer that this user has been performed five horizontal handover attempts. Now the action we can take is to think about redirecting this user to another network or in other words to think about the vertical handover. The same way can be done in case that we have previous vertical handover attempts. This will improve the handover performance very much and make it easy and flexible to have an optimum handover decision.

As it is clear from the previous discussion, we have many scenarios can be happened. Different handover software modules may use this information from different perspectives. This matches our target of using the proposed protocol which is an open architecture protocol.

J. *Forced Handover Flag (F)*

Forced Handover is '1' bit flag length. To understand the purpose of this flag we should think about the trend of 4th generation mobile networks. In the next generation mobile networks the handover decision can be taking not only by the network side but also it can be controlled by the user itself. In other words we should support user controlled handover as well as network controlled handover [19]. We put this flag to make it easy for the user to request from the network his desire to trigger the handover. In this case there is no need from the network side to enter the decision phase as it is finalized from the user side. It is important to ask ourselves this question, which network should be this user switched to? This also may be depending on the user choice as well as it should be included as information in a specific field. This field called Available Network Interfaces (ANI) field which will be discussed later on. This means that if this flag value equal to zero the user leaves the handover decision to be taken by the network side.

K. Uplink or Downlink Direction Flag (UDF)

This one bit flag is used to check the direction of the transferred information; we dedicated this flag to distinguish the direction of the information transfer. The UE can transfer the handover information to the network or the network can exchange the handover information to the user. We can confirm this information simply by checking the IP source and destination addresses relation.

This flag can be used for many useful purposes. For example, this flag can be used in case the current network is capable of determining the available surrounding different technologies for the neighboring or concurrent networks. This information can be provided to the UE to make it easy for the network discovery phase. This of course saves the mobile station battery life very much and helps guide the user to make the smoothly handover. The details of how the serving networks can be able to detect the neighboring are left as future research point, whereas how to feedback this information can be done through our proposed technique.

L. Battery Based Handover Flag (BH)

This one bit flag introduces the possibility of the network to trigger the handover decision mainly based on the UE battery status. The multi-interface terminals have the ability to decide which interface will be available to save the battery lifetime. This is because for the different technologies we have different power consumption levels.

Let's describe this concept in the following example:

Suppose we have multi-interface UE, one interface belongs to WLAN technology whereas the other belongs to UMTS. Now if the user session is done through the UMTS network and the battery indicator becomes weak, at certain battery level a handover decision will be taken to guarantee the session continuity while saving the battery life as possible as we can. For sure we cannot apply this concept without using this flag beside another field that will be used to record the UE battery level (we will discuss it later). The network can take this decision automatically on behave of the user or the UE may take this decision. We can examine the forced handover flag to check whether it is a network controlled or a user controlled handover.

Either the user manually selects to handover because of the battery weakness or the UE itself checks the battery level and takes this action. This is considered as a user controlled handover which can be done by setting the uplink or downlink flag to be equal '0' and in the same time setting the forced flag to be 1. The network can read the battery field information and trigger the handover decision based on the battery weakness. This can be happened in case of the network controlled handover, which can done by setting the forced flag to be equal '0'.

M. Speed Based Handover Flag (SPHF)

The handover decision can be also based on the vehicular speed but this is optional. It can be enabled if we set such flag by one. As we can trigger the handover vertically from one system to another, we need another field to show the speed level. The levels of the speed can be handled by the Speed Based Handover Field (SPH) which we will discuss its details later on.

N. Available Network Interfaces Flag (ANIF)

Whereas we propose an open protocol that can be used for vertical handover, it is very necessary to exchange the information related to the network interfaces, between network elements. This flag gives the possibility of having network interface information in the IP header or not. If this flag value equals to '1', this means that we have information regarding available network interfaces field as it will be described in the following field.

O. Available Network Interfaces Field (ANI)

We can support up to '16' Inter Radio Access Technologies (IRAT). We have 5 bits b4b3b2b1b0. If b4 = 1 this means that, the network interface is not only the existing interface but also we have another available interfaces supported by the UE. Moreover there is a link up/down information for each interface may be added to check if the interface is up or down; this information will be concatenated latter.

To know the status of link up/down, we add a flag that is concatenated to the previous field. This flag can be set by one or zero, if its value equals to one this means the link is up otherwise it means the link is down.

By this way we can get the information related to the link status for each interface, in case of link up or down the current network will be updated. It is very obvious that, this field and its associated flag will exist only in uplink direction. This is because there is no use to put either this field or its associated flag in the downlink direction. However we may use this field in the downlink direction to indicate the presence of another network technology surrounding the user. Of course this is very useful in the network discovery stage which is out of our scope here. Moreover this open the door for new future study of how we can inform the user about its sorrowing networks without needs the UE to do it itself; which means the battery life of UE can be saved very much.

Table III describes the code which corresponding to each network technology. Such as Blue tooth, WLAN, WiMAX, GSM, GPRS, EDGE, UMTS, HSPA, HSPA+, LTE, CDMA2000, Cognitive radio technology and Ethernet.

Table III 'X' indicates if there is another network interface field next to the current one or not. In other words, this bit will be needed to know if there is more than the current technology or not.

In Table III 'Y' is always associated with each interface to represent the network link status, if the state is link up/down. The presence of this bit depends on the value of up/down interface flag check part O. So that we call 'Y' bit as up down indicator bit.

Ethernet protocol is a wired technology however we consider it here. The purpose of using Ethernet technology is our intention to support not only the wireless technology vertical handover but also the wire to wireless and wireless to wire handover. This complies with the concept beyond the fixed mobile converge [20].

The handover in this case is not only concerned about the mobility but also is concerned about the network availability. Indoor users may need to change from WLAN to Ethernet in order to increase the speed without interrupting their service while there is availability for wired Ethernet connection.

When we check the forced flag and found its value equals to '1', we can use the network interface information to confirm that the user needs a forced handover for the technology decoded in the available network interfaces field.

To cope with the concept of open architecture protocol; we suppose that the current handling node may have no idea the current handling network type (in the future any IP core node can handle the traffic regardless of its wireless access network type [21]). To transfer the current network interface information as well, we need to check another flag that is called current network flag.

TABLE III: AVAILABLE NETWORK INTERFACES FIELD.

Value	Description
X00000Y	Blue Tooth
X00001Y	WLAN (IEEE802.11a)
X00010Y	WLAN (IEEE802.11b,g)
X00011Y	WiMAX (Fixed)
X00100Y	WiMAX (Mobile)
X00101Y	GSM
X00110Y	GPRS
X00111Y	EDGE
X01000Y	UMTS
X01001Y	HSPA
X01010Y	HSPA+
X01011Y	LTE
X01100Y	CDMA2000
X01101Y	Cognitive radio technology
X01110Y	Ethernet
X01111Y- X11111Y	Future used

P. *Up/Down Interface Flag*

This flag is used to indicate if there is associated up/down bit for each interface or not.

Q. *Up/ Down Indicator Bit (Y)*

This flag is the one we have been discussed before in the former available network interfaces field section. This is used to represent the associated link status. It is usually concatenated with each available network interface to indicate the status of this interface. And its presence depends on the setting of the up/down flag.

R. *Current Network Flag (CNF)*

This one bit flag is used if we need to mention the current network type. If this flag is set to one, we should add the first available network interfaces field by the current network type. This is regardless of setting the value of the available network interfaces flag to one or zero.

Of course the position of this flag must be preceding the position of available network interfaces flag. If the available network interfaces flag is set to one the 'X' bit in the beginning of the available network interfaces field of the current interface should be also set to one. In this case any additional available network will follow the current network interface field and its associated bits. The position of the current network interface code - if exists - should be the first available network interface.

S. *Service Based Handover Flag (SBH)*

This one bit flag can be used in case we need to take a handover decision based on the service as well. When we set the value of this flag by '1' this means that we can take a handover decision based on service type. For example, suppose a specific user has a WiMAX voice service session and moves to another zone which is covered by both WiMAX and GSM technologies. If the SBH flag equals to one, in this case we can handover the voice session to a GSM system which is very stable and has better quality of service for the voice calls than WiMAX.

This is not a new concept but it is an extension to the concept of IRAT between UMTS and GSM [22] which is based on the events such as 3A and 3C as specified by 3GPP standard. The Radio Network Controller (RNC) gives parameters and thresholds to UE in measurement control message. UE will calculate the triggering condition for each event then reports this information into a measurement report message in case any of these events is triggered. When the RNC receives a measurement report message from UE side it will decide a service based handover according to the triggered event. There is another method which is called periodic reporting can be used by the RNC. In this method the RNC check for a periodic report from UE side, this enables RNC to check the service based handover according to these measurements. Please refer to 3GPP for more details for Periodic Reporting / Event Trigger Reporting Mode [23]. The main difference between 3GPP service based handover and our concept here is that every user can trigger service based handover not only the network side, in other words each user can control the service based handover manually or automatic. User can assign GSM network for its voice session the other user may choose WiMAX for its voice service (cost is another factor). Moreover our technique is not limited to a specific wireless technology but it is open for any radio access technology.

Now what is the scenario in which a specific user needs to handover based on the service? First of all we need to ask ourselves the following questions:

-What is service type this user used?

-Which network is candidate for service based handover?

This of course requires a mapping between different types of services and its candidate networks. As we get informed that we have a user who needs to do handover based on the service we need to answer the first question. The first question can be answered from the session information knowledge. The serving node of course knows the user session; the current network flag may be used for this purpose if it is required, so no need to worry about this problem.

What actually we need to worry about is the mapping criteria between both the service used and the corresponding network that we can use in case service based handover. Table IV describes the priority level applied for the network selection.

T. Service Priority Levels

Priority level field consists of 4 bits length. Table IV depicts the proposed service mapping; the networks or users may modify it according to the need.

This mapping can be kept in the network node based on the network operator needs or by user decision. The UE can carry this information based on the user setting at the terminal side. To control the mapping information we can use a so called service priority levels field which can exist only if the user service based handover flag equals to one. As well as restricting the network interfaces in the available network interfaces field to the networks available for service based handover. In this case we need to make sure the choice of both 'X' and 'Y' bits to guarantee our restriction. Note that the available network interfaces flag must be equal to one so that the other party can read available network interfaces for service based handover. This is valid in case the user controls the handover decision. However there is no need to transfer this information to the user side, in case the network controls the handover decision.

TABLE IV: SERVICE PRIORITY LEVELS.

Priority ID	Priority level
0	N/A (Not Applicable)
1	Level1 (Higher priority)
2	Level2
3	Level3
4	Level4
5	Level5
6	Level6
7	Level7
8	Level8
9	Level9
10	Level10
11	Level11
12	Level12
13	Level13
14	Level14
15	Level15 (Lower priority)

Note that: Not Applicable (N/A) means this network doesn't support the service right now; however it may be available in the future.

U. Handover Option Field Length (HOL)

This field is '9' bits length. In case the value of VFL flag equals '1', we should read this field as a handover option field length value. This field consists of '9' bits and gives the length in bits not in bytes, so when we have '9' bits this means we have a maximum number of '512' bits.

Internet Header Length is the length of the internet header in '32' bit words, thus points to the beginning of the data. Note that the minimum value for a correct header is '5' whereas the maximum length is '15' words. '5' words are used mandatory for the IP header whereas '10' words are used for optional IP header. Each word contains '4' bytes this means total header length in bytes is 4*15 = 60 bytes. '20' bytes are mandatory whereas '40' bytes are used for IP option header. This means we can use up to '40' bytes for handover information. Of course we may not use all these '40' option bytes but we can use some of them. May be the IP option header is used for consecutive different IP options. The standard put two kinds of IP options; one is used for the fixed size whereas the other is used for the variable length [24]. All variable length options type use the option length field. The option length is the number of octets in the option counting the type, length and the option value. To differentiate between the beginning and the end of each option type, we need to be aware of its type and its length. This means that we need to put length field for each option field individually otherwise the option field will have fixed length. A fixed or variable option length can be known from its type such as end of options list which has one byte length. The option type discriminates between a fixed and a variable length option. Whenever the option type is variable length we use the length field however the standard specify this filed to introduce the length in bytes not in bits. This means there is no fraction of bytes that can be used, in other words the variable option should be specified in a group of bytes. The strategy we will use here requires having the length in bits not in bytes, so that we are able to have a fraction of byte. Once again up to '40' bytes can be used for handover IP option, this means we can use up to 40*8= 320 bits. We need '9' bits to represent a maximum length (320 bits). This is the reason in which we use the HOL to be '9' bits.

In case the number of bits doesn't match with the multiple of '8' bits we can add padding with value zero to complement the header with a number of bytes. For example, if we have the whole mobile option field to be '105' bits this means the HOL field length equal to '105' whereas the padding equal to '7' zero padding bits this is because (105mod8= 7). Another example, if we have the whole mobile option field to be '82' bits this means the HOL field length equal to '82' whereas the padding equal to '6' zero padding bits (82mod8= 6). By adding this padding we come to the end of the HOL definition.

Finally, the header must match with multiple of words (32 bits) because of the Internet header length is the length of the internet header measured in '32' bit words.

If there is no other option fields added after the HOL, a single byte option may be used to indicate the end of the option list in the IP header. This might not coincide with the end of the header according to the header length. This option is used at the end of all options, not the end of each option, and need only be used if the end of the options would not otherwise coincide with the end of the IP header. Also the internet header Padding field is used to ensure that the data begins on '32' bit word boundary. The padding always has zero value.

We should differentiate between using the padding in the HOL and using the padding in the IP header. The HOL padding is used to get the boundary of the '8' bit bytes as the end of this handover option field whereas the IP header padding is used to get the boundary of the '32' bit words. In other words the HOL padding uses (mod8) whereas IP header padding uses (mod32).

V. Battery Level Indicator Field (BL)

The length of this field is '3' bits. The battery indicator field has indication about the battery level. As we have '3' bits this means we can discriminate up to eight battery levels. Level zero means we have the strongest battery indicator which is encoded as '000' whereas level '7' is encoded as '111' and indicates to a very weak battery level. Table V gives the detailed description for this field. The presence of this field depends on the value of the battery based handover flag. If the value of this flag is '1' this means we can get the battery level information by reading the battery indicator field otherwise we will not put this information. Note that, this information can be set from the UE side and read by the network to take a handover decision based on the battery level. Suppose we have a UE with a very weak battery level. This terminal is currently connected to a WiMAX network while it discovers a WLAN network. Because the WLAN interface consumes less power as compared to WiMAX interface, the handover decision can be taken from WiMAX to WLAN network to save battery life time as we can. This handover can happen irrespective of the user mobility state, in other words the mobility status is not the only triggering factor for the handover. Of course the vehicular speed also affects the choice of the destination network so it should be considered. Moreover the user may be trigger the handover based on this information from his side. In this case the forced handover flag expresses the desire of the user to handover and the cause may be due to battery level indication (indicator). Thanks to this proposed open protocol that achieves the possibility of taking the handover decision based on the battery life time.

TABLE V: BATTERY LEVELS FIELD.

Value	description
000	Level 0 very strong battery level indicator
001	Level 1
010	Level 2
011	Level 3
100	Level 4
101	Level 5
110	Level 6
111	Level 7 very weak battery level indicator

W. Speed Based Handover Field (SPH)

The length of this field is '4' bits which give us the ability to divide the mobile movement speed into '16' levels. According to this speed level we can judge the appropriate target network that is elected to handover. Table VI states all the levels description. Four bits is enough to differentiate among these '16' vehicular speed levels.

This field is directly put after confirming the desire to include the speed based handover, by setting the speed based handover flag to be one. This means that this field is option; its presence depends on the speed based handover flag. If that flag value equals to zero this indicates that the Speed based handover field will not be used, because there is no need to put it down.

As we can deal with a variety of systems that may be a Personal Area Network (PAN), WLAN, WiMAX, Public Land Mobile Network (PLMN) or satellite so we need more precise levels for accurate actions. This explains why we have '16' levels in table VI, which introduces the following proposed classes of mobility.

Here we have two options, the first one is to transmit the absolute value of the vehicular speed whereas the second one to transmit a range in which the vehicular speed moves in. we prefer the second choice as it will save the header length as well as the range is enough to take accurate action.

We also left '7' more levels for future use, this is because the open architecture for the proposed technique not only supports all the existing technologies but also supports future technologies. Moreover the calculation of the network performance regarding the UE speed is left as a future study.

Note: We need to confirm that, there is a big difference between both SPH and HC fields. SPH not only depends on HC but also it depends on other key factors. This is because right now, the handover concept depends not only on the mobility factor but also it depends on other factors. Factors such as, requested service, battery level and more others can trigger the handover; many of them not depend on the mobility. HC can be used for other purposes in the handover decision.

TABLE VI: MOBILITY CLASSES FIELD.

Value	Description of mobility classes Kilo meter per hour
0000	Stationary1: 0 km/h
0001	Stationary2: > 0 km/h to 1Km/h
0010	Pedestrian1: > 1 km/h to 5 km/h
0011	Pedestrian2: > 5 km/h to 10 km/h
0100	Vehicular1: 10 to 60 km/h
0101	Vehicular2: 60 to 120 km/h
0110	High speed vehicular1: 120 to 250 km/h
1111	High speed vehicular2: 250 to 350 km/h
1000	High speed vehicular3: 350 to 1000 km/h
1001	Future use
1010	Future use
1011	Future use
1100	Future use
1101	Future use
1110	Future use
1111	Future use

IV. CASE STUDY AND CONCEPTUAL PROOF

We have two options for using our proposed scheme, either to have a complete handover protocol that treat with all handover phases we discussed before or to use it only in the handover preparation phase. In other words, our proposed scheme has two working modes; Integrated Mode (IM) and

Stand-alone Mode (SM). In IM working mode our protocol can be compatible with handover phases two and three of the other existing VHO protocols whereas the SM working mode cover the three handover phases of its own. Most of the current vertical handover protocol studies focus only on handover phase three while ignoring the other two phases. In this paper we focus on IM handover mode.

We also have the following two information transfer modes: Associated Handover Messaging Mode (AHMM) and Non-Associated, Separate or Independent Handover Messaging Mode (SHMM). In AHMM we can transfer the handover messages in any IP packet transferred from one node to another whereas SHMM has independent IP packet that is constructed specially for handover purposes, however both modes have the same functionality and achieve one target.

We study the integration of our proposed scheme with the selected IMS-SIP vertical handover protocol that is introduced by Kumudu [12]. This is to test the integration feasibility of our scheme with the existing vertical handover protocols. Kumudu et al. assume that the user manually triggers the handover which is executed using IMS-SIP protocol. So that the signaling flow of IMS-SIP was not complete and they didn't include the preparation handover phase (see Fig. 2).

Two signaling messages are added using our proposed protocol. After that the handover is triggered based on the user or the network. The user controlled handover can be triggered manually by the user interaction or automatically by the mobile terminal software module. In both cases the network can detect the user side handover desire by using the forced handover flag we discussed before in the previous section. Even the triggering comes from the user side it will be complete automatically using our protocol which gives higher flexibility for information transfer. Fig. 3 shows a complete signaling flow after combining our scheme with IMS-SIP protocol in AHMM mode whereas Fig, 4 shows it in the SHMM mode.

We postulate that a user controlled handover is required, for example the battery level of the mobile terminal becomes week while the user connected to UMTS Terrestrial Radio Access Network (UTRAN) interface. Now the information belong to the terminal available interfaces are reported to network side through ANI field moreover the user terminal sends the battery information to the network side in BL field. After that a battery based vertical handover is triggered from UTRAN to WLAN interface. After that the network sends the second message to the UE which indicates its readiness for handover and asks the terminal to prepare the WLAN interface to be ready for the handover execution phase. So we have two messages each one consists of 48 bits. So we have 48mod32 = 16 padding bits. In this case the total message length equals to 64 bits or 8 bytes.

AHMM mode has small number of bits as compared to SHMM mode. For example, to send the same amount of handover information we need 20 IP header extra bytes for SHMM moreover the layer underneath header is added as well. Beyond this, depending on the transmission medium, an additional overhead of 34 bytes are added if the IEEE 802.11 Media (Media Access Control) MAC layer is used and a minimum overhead of 6 bytes are added if the UTRAN is used. Furthermore, no header compression option is considered at UTRAN Packet Data Convergence Protocol (PDCP) layer to match the same test criteria. This means in AHMM mode the message length equals to 8 bytes whereas in the SHMM mode it equals to 34 bytes.

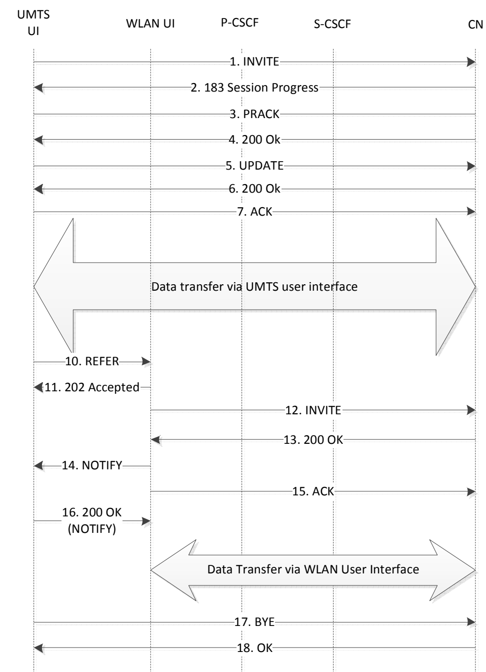

Figure 2. IMS-SIP signaling flow.

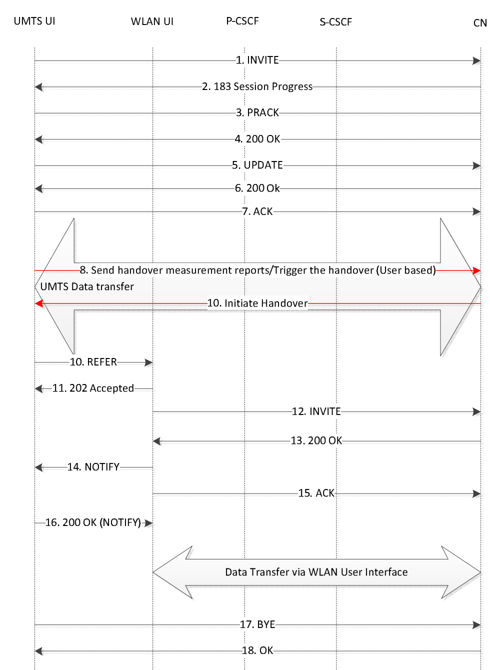

Figure 3. IMS-SIP signaling flow with AHMM mode.

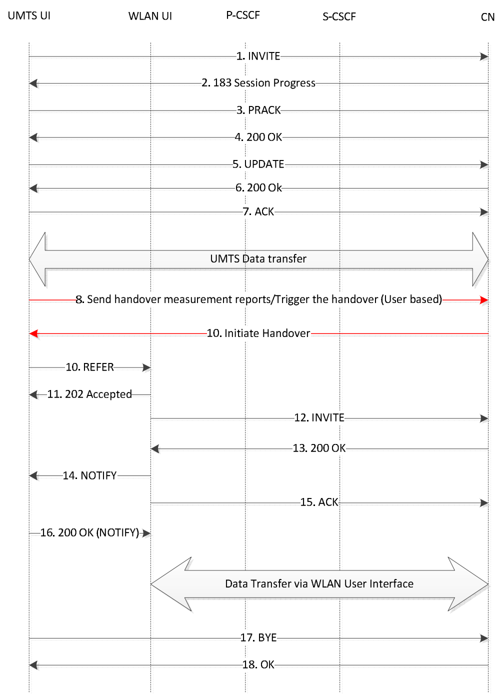

Figure 4. IMS-SIP signaling flow with SHMM mode.

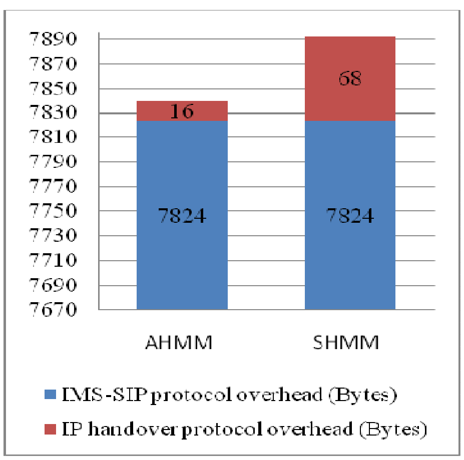

Figure 5. Comparison between our prposed protocol in AHMM and SHMM modes and IMS-SIP protocol.

According to the previous case study we can calculate the signaling overhead cost percentage for both AHMM and SHMM as shown in Fig. 5. The signaling overhead cost for AHMM equals to 0.204%whereas for SHMM it equals to 0.861% which increases a little bit as predicted before. The last results indicate that the proposed protocol has negligible cost effect on the signaling overhead whereas it guarantees a quantum leap toward overcoming next generation network challenges.

The new innovation here is that, it becomes possible for IMS-SIP protocol to execute the vertical handover phase based on new metrics triggering conditions such as battery level status which becomes easy now to be reported using our protocol.

V. CONCLUSION

Most of the current handover protocols studies focus on the handover execution phase and others are interested in the decision making criteria phase while ignoring how the network discovery and measurement reporting phase are done. In this paper we introduce logical visibility simple handover information messaging exchange scheme. The proposed scheme is designed especially to cover phase one vertical handover in which the network discovery and handover parameters metrics are easily reported. Our concept based on the separation of phase one handover and designing an independent and open protocol for it. In other words our scheme can coexist with other handover protocols and algorithms. So that it can provide a complete handover protocol that keeps the flow of information seamlessly without re-modifying the existing infrastructure. The advantages of this protocol come from associating the handover messages with the IP header that is used for transferring the traffic payload itself. This means that the proposed protocol is open for integration with any handover protocol. To cope with the next generation mobile networks demands we select the IP protocol. Adding some modification to the IP header gives the ability to support both vertical and horizontal handover. This work is mainly used for the handover measurements exchange and more intelligent handover decision making. By using the proposed protocol we can take the handover decision based on new smart concepts such as battery life time, vehicular speed, service type, user desire and other metric as discussed before. Moreover a ping pong vertical handover effect is treated by using handover counter Field. Our protocol also supports the transparency messaging transfer of the user terminal events which reflects all user incidents as a mirror. Events such as the battery status, vehicular speed and user manually requesting handover are applicable using battery, speed and forced handover fields respectively.

We also introduce a signaling integration case study between our proposed protocol and MIS-SIP protocol which gives a complementary solution and provides benefits from the new added handover metrics. We introduce two working modes AHMM and SHMM. In AHMM we are exploit the already transferred UMTS data in current active session for handover information exchange. In spite of SHMM uses non association approach that requires constituting special signaling messages, it also gives very low signaling overhead as compared to the cost of MIS-SIP protocol. We can conclude from our case study that the signal overhead cost of AHMM much better than SHMM however both AHMM and SHMM are better than MIP-SIP.

This protocol is an open architecture, so that many future studies can be done to search how this protocol can be integrated with the other handover protocols. This new protocol not only can be integrated with vertical handover protocols but also it can be integrated with horizontal handover protocols as well. This paved the way for many new future works. Moreover this protocol can be extended to a complete handover protocol. We call this complete handover protocol working mode SM. The SM includes all handover phases that we leave as a future study. Our proposed protocol is operational applicability so its implementation and metrics performance can be done in the future

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Malak Z. Habeib is a Ph.D candidate at the Electronics &Communications Engineering Dept., Faculty of Engineering, Ain Shams University, Cairo, Egypt since 2006. He obtained his B.Sc. and M.Sc. from Helwan University in 2000 and 2004 respectively.

Eng. M. Habeib areas of interest include Telecommunication Networks, Mobile Systems, IP Networks, Dynamic frequency allocation where he has a list of publications.

Hussein A. Elsayed is an Assistant Professor at the Electronics & Communications Engineering Dept., Faculty of Engineering, Ain Shams University, Cairo, Egypt since 2009. He obtained his B.Sc. and M.Sc. from Ain Shams University in 1991 and 1995 respectively; and the Ph.D. from Electrical Engineering Dept., City University of New York, New York, NY, USA in 2003. Since then, he served in different positions and built both practical and theoretical skills in the area of Communication Networks.

Dr. Elsayed is an IEEE member since 1991. His areas of interest include Telecommunication Networks, Mobile Systems, Sensor Networks, and Network Security, where he has a long list of publications. Throughout these years of experience, he obtained different grants and awards from both academic and industrial sources.

Salwa H. Elramly graduated 1967, obtained MSc. Degree 1972 from the Faculty of Engineering, Ain Shams University, Egypt, then her PhD degree 1976 from Nancy University, France.

She is now Professor Emeritus with the Electronics and Communication Eng. Department, Faculty of Engineering, Ain Shams University; where she was the Head of the Department (2004-2006). Her research field of interest is Communication Systems and Signal Processing specially Speech Signal Processing, Digital Signal Processing, Wireless Communications, Coding, Encryption, and Radars. She is a Senior Member of IEEE and Signal Processing Chapter Chair in Egypt.