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Application-Oriented Media Independent Vertical Handover Decision (AMIVHD) in 4G Heterogeneous Wireless Networks

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ABSTRACT

With the advance of various wireless access technologies, the demand for a mobile user equipped with multiple air interfaces simultaneously executing diverse applications emerged. In such network environments, per-application mobility management is a key to allow each application of an end user device to dynamically and fully take advantage of the most suitable access technology. In this paper an application-oriented media independent vertical handover decision (AMIVHD) mechanism for video transmission by a mobile user over heterogeneous network environment is implemented. The proposed concept enables the triggering of vertical handover decisions based on the quality measurements of video transmission in wireless networks. For application based handover decision, mobility management as well as transport/application protocol control adaptation for handover performance optimization is made with the help of Media Independent Handover (IEEE 802.21) Frame work.

Through the simulation results, it is shown that multi-layer handover triggering of the proposed concept enhances the QoS of the application services. The handover decisions are made when the QoS requirements of an application is not satisfied as well as when a mobile user moves out of the current access network in overlay network environments. It is also presented that per-application handover based on the proposed platform enhances the QoS of the application services compared to the handover approaches which make every on-going service flows handover together to the same access network.

Keywords
AMIVHD, Vertical Handover Decision, Wi-Fi, WiMAX, UMTS.

1. INTRODUCTION

The current standards of Telecommunication are driven to replace with 3G in upcoming years. This future cellular network is named as 4G. The objective is to offer seamless multimedia services to users accessing an all IP based infrastructure through heterogeneous access technologies. The current trends in mobile computing mainly include Wi-Fi, WiMAX and LTE. The ability to share information across a wireless platform is becoming more vital to the today's business communication needs. The 4G network will consist of internet protocols such as to facilitate the subscribers by enabling the selection of every application and any environment. In 4G cellular networks a high bandwidth with high data rate is required, also in 4G a quicker and optimized strategy of handover is required to make the clear and reliable communication. The 4G network system will run with the cooperation of 2G and 3G and also will impart IP based wireless communication. The main target in 4G will be video streaming on IP based protocol, such as IP TV. Accessing information anywhere, anytime, with a seamless connection to a wide range of information and services, receiving a large volume of information, data, pictures and video will be supported.4G systems should offer a peak speed of more than 100Mbits per second in stationary mode with an average of 20Mbits per second when travelling which would be at least 10 times that of 3G systems. This will quicken the download time of a 100-Mbyte file to one second on 4G, from 200 seconds on 3G, enabling high-definition video to stream to phones and create a virtual reality experience on high-resolution handset screens.

In cellular mobile networks, there are two major issues are data rate and mobility, bandwidth and coverage. According to these two issues we can divide networks into two different technologies.

1. Technologies with low data rate and mobility.

2. Technologies with high data rate and bandwidth with small coverage

Some of the emerging technologies are discussed below

Wi-Fi (Wireless Fidelity) IEEE 802.11:

Wi-Fi is a mechanism that allows electronic devices to exchange data wirelessly over a computer network. A device enabled with Wi-Fi, such as a personal computer, video game console, Smartphone, tablet, or digital audio player, can connect to a network resource such as the Internet via a wireless network access point. An access point (or hotspot) has a range of about 20 meters (65 ft) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio signals or a large area, as much as many square miles, covered by multiple overlapping access points. Wi-Fi allows cheaper deployment of local area networks (LANs). Also spaces where cables cannot be run, such as outdoor areas and historical buildings, can host wireless LANs. Manufacturers are building wireless network adapters into most laptops. The price of chipsets for Wi-Fi continues to drop, making it an economical networking option included in even more devices. Different competitive brands of access points and client network-interfaces can inter-operate at a basic level of service. Products designated as "Wi-Fi Certified" by the Wi-Fi Alliance are backwards compatible. Unlike mobile phones, any standard Wi-Fi device will work anywhere in the world.

WiMAX (Worldwide Interoperability for Microwave Access) IEEE 802.16:

The fiber optic transport services providing the high bandwidth and data rates is replaced by WiMAX wireless technology all across the world. WiMAX is emerging technology to fulfill the High data rate and QoS requirements of the customers, also it is the cheap deployment of voice Services with no need of line of sight wireless channel. WiMAX signals have the property to adopt the atmospheric conditions everywhere. WiMAX electromagnetic waves also offer the support of adoptive coding and different operation modes, so voice and data services can easily be transported by WiMAX network platform. WiMAX operate same like Wi-Fi but Wi-Fi operate with some limitation like base band technology and it will cover only 100 feet radius with slow speed. WiMAX covers 50 km radius with speed of 70 Mbps. The objectives of WiMAX are superior performance, flexibility, advanced IP-Based architecture, attractive economics. WiMAX can provide at-home or mobile Internet access across whole cities or countries. In many cases this has resulted in competition in markets which typically only had access through an existing incumbent DSL (or similar) operator. Additionally, given the relatively low costs associated with the deployment of a WiMAX network (in comparison with 3G, HSDPA), it is now economically viable to provide last-mile broadband Internet access in remote locations.

LTE (Long Term Evolution) 3GPP Release 8:

LTE (Long Term Evolution) is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM / EDGE and UMTS / HSPA network technologies, increasing the capacity and speed using new modulation techniques. The standard is developed by the 3GPP (3rd Generation Partnership Project). LTE is a standard for wireless data communications technology and an evolution of the GSM/UMTS standards. The goal of LTE is to increase the capacity and speed of wireless data networks using new DSP (Digital Signal Processing) techniques and modulations that were developed around the turn of the millennium. Its wireless interface is incompatible with 2G and 3G networks, so that it must be operated on a separate wireless spectrum. The access scheme for uplink is DFTS-OFDM and for downlink is OFDMA. The bandwidth for LTE is 1.4, 3, 5, 10, 15, 20MHz. The data type is all packet switched data for both voice and data. The applications of LTE are voice, sms, instant messaging, internet browsing, video streaming, social networking, online navigation, email, health surveillance, vehicle tracking, positioning and tracking.

2. VERTICAL HANDOVER DECISION – ISSUES

2.1 Handoff Scheme for Heterogeneous IPv6-based Wireless Networks:

Mobility management, with provision of seamless handoff and quality of service (QoS) guarantees, is one of the key issues in next generation or 4G wireless networks (NGWN/4G). Current trends in communication networks evolution are directed towards an all-IP principle in order to hide heterogeneities and to achieve convergence of various access networks. Several IPv6-based mobility management schemes have been proposed for service continuity in NGWN/4G. However, these schemes have some well-known disadvantages such as signalling traffic overhead, high packet loss and high handoff latency, thereby causing a user-perceptible deterioration of real-time applications. [5] proposes an efficient handoff protocol for NGWN/4G, called Handoff Protocol for Integrated Networks (HPIN), that alleviates service disruption during handoff. HPIN is a one suite protocol that performs local mobility management, fast handoff, context transfer and access network discovery. Performance evaluation based on numerical results shows that the proposed scheme performs better than existing schemes.

2.2 Media-Independent Handover in heterogeneous networks:

New Internet applications and services are constantly being introduced. To be successful, they must guarantee a specific quality-of-service (QoS) to the user. Modern access systems have the capability to full fill this requirement, but the problem is more complicated in heterogeneous environments, where transition between diverse types of access technologies (e.g., Bluetooth, Wi-Fi, WiMAX, CDMA, GSM, GPRS, and UMTS) can lead to reduced performance, mainly due to incompatibility problems. This leads to a requirement to make the transition from one access network to another as seamless as possible for the user, that is, to offer a seamless mobility experience. With seamless mobility, users can exploit a variety of access networks to best meet their charging and QoS requirements, while at the same time, operators can offer compelling, value-added services, as well as improve their network capacity and the availability of their services.

Seamless mobility can be achieved by enabling mobile terminals to conduct seamless handovers across diverse access networks, that is, seamlessly transfer and continue their ongoing sessions from one access network to another. A seamless handover is typically characterized by two performance metrics:

•The handover latency should be no more than a few hundred milliseconds.

• The QoS provided by the source and target systems should be nearly identical (or the user should not perceive any change to his communication experience after the handover).

These two performance requirements are not trivial to satisfy when different access networks are combined in a single architecture, because minimum service data flow interruption usually can be achieved by networks with tight-coupling mechanisms across them (such as GSM EDGE radio access network (GERAN) and UMTS terrestrial radio access network (UTRAN), specified by 3GPP), and QoS provision at the target system requires mapping of specific QoS attributes from the source network.

In general, before seamless inter-radio access technology (inter-RAT) mobility is widely deployed in modern heterogeneous networks, many technical challenges still must be addressed. These challenges are the main focus of [6], in which they study the new trends and technical advances associated with seamless mobility in heterogeneous networks.

2.3 Seamless Handover in Heterogeneous networks:

[4] deals, how to guarantee seamless handover service and QoS over WLAN-WiBro heterogeneous networks. Especially, Multimedia Messaging Service (MMS) provides the means for delivering multimedia messages among mobile users in store-and-forward fashion. Furthermore, MMS also provides

mobile users with the possibility to exchange multimedia messages with the Internet users and has been seen as the key application in its entry into mobile network services. The WLAN-WiBro heterogeneous networks will particularly make MMS more ubiquitous, bringing benefits to both service providers and mobile users. In addition, the mandatory part of the current WLAN MAC scheme is called Distributed Coordination Function (DCF) which uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). DCF is supposed to provide a channel access with equal probabilities to all traffic flows contending for the channel access in a distributed manner, hence it does not guarantee QoS. In order to support QoS, a number of QoS-aware MAC schemes have been introduced to extend DCF which has not guaranteed any service differentiation. However, none of those schemes full fill both QoS features and channel efficiency although these support the service differentiation based on priority. Therefore, [4] proposes both the inter-working architecture for ensuring seamless multimedia service and the wireless MAC scheme for ensuring QoS in WLAN-WiBro heterogeneous networks.

2.4 Per-application mobility management:

In [1], a comprehensive architectural platform for mobility management that allow end-users to dynamically and fully take advantage of different access networks is proposed. Assuming that an MN is equipped with an air-interface capable of simultaneous access to multiple networks and running one or more applications at the same time, It propose the concept of per-application mobility management, that is, an access network is specifically selected for each application according to its different QoS perspective. Indeed, the concept of per-application mobility management is aligned with the motivation of the emergence of various access network technologies: no single network technology can satisfy all different QoS constraints of various applications.

2.5 Vertical handoff in heterogeneous networks:

One of the major design issues in heterogeneous wireless networks is the support of vertical handoff. Vertical handoff occurs when a mobile terminal switches from one network to another (e.g., from WLAN to CDMA 1xRTT). The objective of [2] is to determine the conditions under which vertical handoff should be performed. The problem is formulated as a Markov decision process. A link reward function and a signalling cost function are introduced to capture the trade of between the network resources utilized by the connection and the signalling and processing load incurred on the network. A stationary deterministic policy is obtained when the connection termination time is geometrically distributed. Its numerical results show good performance over two other vertical handoff decision algorithms, namely: SAW (Simple Additive Weighting) and GRA (Grey Relational Analysis)

3. APPLICATION-ORIENTED MEDIA INDEPENDENT VERTICAL HANDOVER DECISION (AMIVHD)

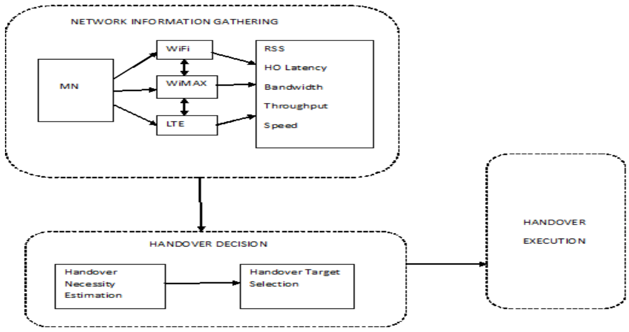

Fig. 1. Block diagram of AMIVHD

In, the network information gathering phase, a mobile terminal (MT) searches for reachable wireless networks. A multimode (equipped with multiple access network interfaces) MT must activate the interfaces to receive service advertisements broadcasted by different wireless technologies. A wireless network is reachable if its service advertisements can be heard by the MT. The simplest way to discover reachable wireless networks is to always keep all interfaces on. It is critical to avoid keeping the idle interface always on since keeping the interface active all the time consumes the battery power even without receiving or sending any packets. The network parameters considered are RSS, HO latency, bandwidth, throughput and speed.

The handover decision is subdivided into two phases namely,

- Handover necessity estimation - It determines whether a handover is necessary to an available network. Two situations when a mobile node seeks handover are:
  - A mobile node moves out of the coverage of serving station.
  - A mobile node looks for high speed multimedia applications.
- Handover target selection - It chooses the "best" network among the available network based on a set of criteria.

In the handover execution phase, handover is executed to the selected target is shown in fig.1.

In heterogeneous wireless networks, handoff can be separated into two parts: horizontal handoff (HHO) and Vertical Handoff (VHO). A horizontal handoff is made between different access points within the same link-layer technology such as when transferring a connection from one BS to another or from one AP to another. A vertical handoff is a handoff between access networks with different link-layer technologies, which will involve the transfer of a connection between a BS and an AP.

During the handoff decision phase, the mobile device determines which network it should connect to. During the handoff execution phase, connections need to be rerouted from the existing network to the new network in a seamless manner. During the VHO procedure, the handoff decision is the most important step that affects mobile host's communication. An incorrect handoff decision may degrade the QoS of traffic and even break off current communication.

Handoff algorithms in heterogeneous wireless networks should support both HHO and VHO and can trigger HHO or VHO based on the network condition. What should be noted is that, because of the uncertainty of the network distribution and the randomness of mobile host's mobility, it is impossible to forecast the type of the next handoff in advance. Thus, handoff algorithms in heterogeneous wireless networks must make the appropriate handoff decision based on the network metrics in a related short time scale.

3.1 Heterogeneous handover

Handover between different networks is called heterogeneous handover. Initially network discovery take places. Heterogeneous handover takes place depending on the metrics like bandwidth, rss, data rate etc. If a mobile node is initially getting service under the coverage of a Wifi and while undergoing mobility it comes out of its coverage then it detects other neighbouring networks and hands over to the network that has better bandwidth. If the RSS of the current network where the mobile node is situated drops below the threshold value then also heterogeneous handover takes place. For example if mobile node uses BS and it moves out of coverage, and it finds the networks AP(WiFi), BS(WiMax) and eNB(LTE) as its neighbouring networks. Then the best network is chosen and handover takes place to that network. The flow diagram for WLAN-WiMAX-LTE Vertical Handover is shown in fig.2.

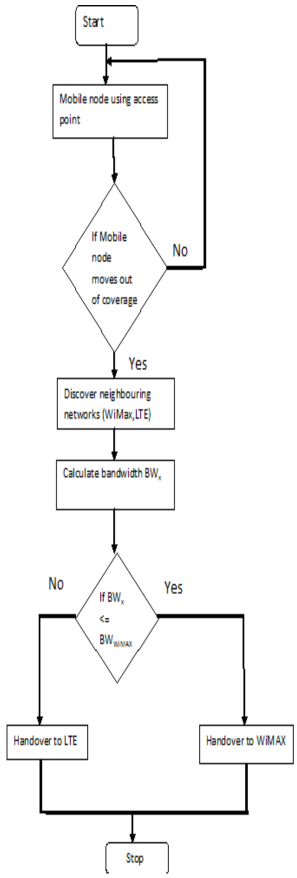

Fig. 2. Flow diagram of WLAN-WIMAX-LTE Vertical Handover

3.2 Handover procedure

It is a set of procedures that will act as an Interface manager which controls the trigger mechanism between different types of network interfaces. The trigger mechanism will function based on different types of events that are obtained from MIHAgents. In this project seven types of events are handled in this module, they are;

- Register_MIH
- Link_Detected
- Link_UP
- Link_Down
- Received_New_prefix
- Capability_Discover.confirm
- MIH_Register.confirm

3.2.1 Register_mih

Input: Appropriate Link for connection
Output: Local MAC response to the mobile node
Algorithm:

1) Get the link_ID , interfaces in the network using get_status()function.
2) For each interface link retrieved above, do the following steps
3) Discover the capability of link using mih_capability_discover() function

4) Find the events (Link Detected, UP, Down) corresponding the respective link
5) Register the above events to the local machine of the mobile node using mih_event_subscribe() function.

3.2.2 Link detected event

Input: Event information about link detected
Output: Connecting to the detected link, if it is better than current one
Algorithm:

1) Get the interface and neighboring interface in the network.
2) For each neighboring network, do the following steps
3) Search for an interface with status LINK_STATUS_UP
4) If it is a new interface, compare the link with the connected interface and choose the better interface based on the application access by the user. If the new interface is not better, go to step 6,else do the following steps
5) Configure the new link detected using mih_configure_link () function.
6) Print the status of the link connected.

3.2.3 Link Down Event

Input: Event information regarding link down
Output: Connecting to another better network
Algorithm:

1) Check whether the connected link is down, if so do the following steps else return
2) Get the flows and interfaces in the network using get_interfaces().
3) Find the best interface among the neighbouring interfaces.

[In this scenario, we set the network priority as, priority decreases downwards)
i.ethernet
ii.wifi
iii.wimax
iv.umts

The network with the highest priority is taken as the best network.]

If we found set variable found =1 and go to step 4
else go to below step 6

4) If all the neighbouring networks are not processed, compare the remaining with the best interface found in the above step and find the best interface in the neighbouring interface list.
5) Scan all the interfaces of the network and search for the best one.
6) Configure the link found in the one of the above steps.

3.2.4 New Prefix Entry

Input: Data containing information about prefix
Output: Redirect the flows to interface regarding the new prefix.

Algorithm:

1) Get the MAC address for which we received a new prefix using TclObject::lookup () function.
2) Check if that is a better interface and redirect flows using the below steps
3) Send capability request on new interface using the method send_cap_disc_req().
4) Get the node of the new interface and compare the new interface with neighbouring interfaces.
5) Redirect the flow towards the new node found in the above steps.

3.3 VIDEO TRAFFIC

A video stream consists of group of pictures (**GOPs**) which are composed of only one intra-coded (**I**) frame and multiple predictive-coded (**P**) frames and bidirectional predictive-coded (**B**) frames. These picture types or frame types are various kinds of video compression algorithms.

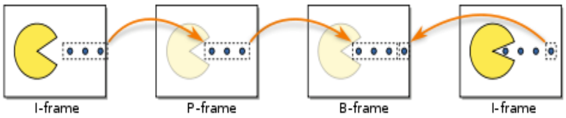

Fig.3 A sequence of video frames, consisting of two key frames, one forward-predicted frame and one bi-directionally predicted frame.

- **I**- frames are the least compressible but don't require other video frames to decode.
- **P**- frames can use data from previous frames to decompress and are more compressible than I - frames.
- **B**- frames can use both previous and forward frames for data reference to get the highest amount of data compression.

4. EXPERIMENTS AND EVALUATION

The sample video consists of 2001 frames. The analysis of video sent from the router and the video received by the user is shown in Table 4.1.

Table 4.1 Frame loss in homogeneous network

Specification	I-frame	P-frame	B-frame	Total
No of Packet sent from the router	1215	924	2467	4607
No of Packet lost during transmission	0	0	0	0
No of Frames sent from the router	223	445	1332	2001
Frame lost during transmission	0	0	0	0

The analysis result over the video sent from the router and the video received by the user is shown in Table 4.2.

Table 4.2 Frame loss in heterogeneous networks without AHDM

Specification	I-frame	P-frame	B-frame	Total
No of Packet sent from the router	1215	924	2467	4607
No of Packet lost during transmission	77	26	43	147
No of Frames sent from the router	223	445	1332	2001
Frame lost during transmission	33	21	35	90

4.1 Video traffic in heterogeneous network

The same video is transmitted from the router to a mobile user in the same heterogeneous n/w environment (Fig.4) while the user moves across different network base stations.

Fig.4. Video frames received by the mobile user with Application based handover decision mechanism (AHDM)

The analysis result over the video sent from the router and the video received by the user is shown in Table 4.3.

Table 4.3 Frame loss in heterogeneous networks with AHDM

Specification	I-frame	P-frame	B-frame	Total
No of Packet sent from the router	1215	924	2467	4607
No of Packet lost during transmission	5	4	8	17
No of Frames sent from the router	223	445	1332	2001
Frame lost during transmission	1	2	5	8

The video frames that are received by the mobile user with and without application based handover mechanism are shown in the table 4.2 and table 4.3 respectively. Since, the quality of a video is completely depends on the number of i-frames lost, the video in table 4.2 seems with less quality when compared to that of in table 4.3. This is because, in our scenario the mobile user starts to receive video frames from the wimax base station, and then it starts to move away from the wimax base station. At a certain distance the user will detect a wifi network.

If there is no application oriented handover installed, the user will continue to receive data through the wimax base station. In this case, the 'p' and 'b' frames of the video are transmitted without any packet loss. Whereas the loss of i-frame packets will increase as the user moves away from base station, since the QoS required for i-frame transmission is not enough.

But, in the case of application oriented handover mechanism, the MIH agent in the user's mobile system will have the knowledge about the handover decision with respect to the video transmission. So, when the user moves away from the wimax base station, after it detects the wifi network, the handover decision mechanism commands the user's MIH agent to get connected to the wifi base station, due to which the total i-frame loss will get minimized. Hence the user will receive the video with better quality.

5. CONCLUSION AND FUTURE WORK

In the next generation wireless networks, overlaid multiple wireless access systems with significantly different capabilities coexist. In such network environments, mobiles devices equipped with multiple air interfaces may execute diverse applications simultaneously. In this project, concept leveraging end-to-end mobility management and cross-layer technique is implemented in order to accomplish the following objectives:

1. Enabling the effective multi-layer triggering for handover decisions.
2. Enabling per-application handover decision and network selection.
3. Enabling transport and/or application specific control and adjustment when handover occurs.

The future direction can be:

1. The proposed application based handover decision mechanism is designed based on handling only a single application type which can be extended to handle multiple applications in a mobile node.

2. There are various other QoS to be considered like missed beacons and number of packets received with error. In our simulations we have considered only the number of dropped packets and the RSSI as the QoS parameters.

3. Also, the authentication and the other security aspects when a mobile node registers with a base station can be considered.

6. ACKNOWLEGEMENT

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