Guarantee QoS in Coexistencee of High Altitude Platform System and WiMAX TerrestrialSystem

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Abstract--The coexistence performance when high altitude platform (HAP) and terrestrial WiMAXsystems coexist within the same coverage area sharing a common 5.75 GHz frequency band is investigated. In this paper, the investigation of the possibility of utilizing the HAPS service in order to provide WiMAX coverage in the urban area is conducted. Taking into consideration of the acquired results, utilizing the isolation technique is one of the proposed solutions in order to enhance the system capability. This paper investigates the interference to noise ratio (INR) power control to provide coexistence performance. HAP can provide large coverage area at altitude 17-21km while WiMAX is used for mobile wireless network and can operate in unlicensed frequency band. By using dynamic spectrum access such as power control, these two systems can work effectively and efficiently. The modulation of HAP is varying from BPSK to 64QAM to identify which modulation need power control. For BPSK, the power control is not required. Meanwhile for 64QAM, power transmit from HAP is greater than terrestrial WiMAX. Therefore, INR power scheme was used to adjust the terre3trial power. By applying power #ontrol, better coexistence performance can be achieved.

Index Terms—HAP system, WiMAX System,HAP, Power control

I. INTRODUCTION

NOW days, communication services are in high demand and widely used. It means that a large amount of wireless infrastructure is required to meet the significant demand on the radio spectrum. There are three types of communication systems till now, terrestrial communication system, satellite communication systems, and the modern technology of communication is HAP communication system.

The High Altitude Platform systems (HAPS) are airships or platforms with a massive potential which foremost defined in 1997[1, 2]. HAPs as a new solution for delivering wireless broadband , have been recently proposed for the provision of fixed, have suggested to as way to providing 3G mobile services in stratosphere at an altitude of 17 km to 21 km[3-5].HAPs can act as base-stations or relay nodes, which may be effectively regarded as a very tall antenna mast [6].Also at this altitude, they can maintain a quasi-stationary position and support payloads to deliver a range of services: principally communications, and remote sensing, Communications services including broadband, WiMAX(Worldwide Interoperability for Microwave Access), 3G, and emergency communications, as well as broadcast services, are under consideration.

HAPs are capable of long-endurance performance, and their potential to provide commercial communication services to terrestrial subscribers has been investigated extensively over recent years [7, 8]. This modern communication solution (HAPs) has advantages of both terrestrial and satellite Communications [5]. Due to distinct features of the novel HAP system, which are different from those of the conventional terrestrial and satellite systems, such as high receiver elevation angle, line of sight (LOS) transmission, would contribute to a better overall system performance, greater system capacity and cost-effective deployment. Furthermore, a single aerial platform can replace a guarantee QoS coexistence of HAP and WiMAX system alarge number of WiMAX terrestrial base stations. The rapid deployment of HAP is an additional advantage in terms of time-to-market and in disaster and emergency situations.WiMAX is a standard-based wireless technology for providing high-speed, last-mile broadband connectivity to homes and businesses and for mobile wireless networks ranging from 2 to 66 GHz in frequency[9].If deployed from HAPs, WiMAX will serve a larger coverage area whilst reduce the amount of communication infrastructure normally needed for terrestrial networks and employing the unique feature of HAPs.

When HAP and terrestrial WiMAX are in the same coverage area, it is known as coexistence scenario. The HAP will be coexisting with a primary terrestrial system

and give an effect to the system performance. Therefore the dynamic spectrum management is used to allow these systems to share the same frequency band and ensure that they can work together effectively and efficiently also share the same frequency 5.75GHz.

The paper is organized as follows; HAP network architecture in section II is described. Terrestrial WiMAX systems covered in section III and section IV, described coexistence of HAP and WiMAX scenario. Performance of coexistence scenario gives on section V and analysis of interference from HAP to terrestrial WiMAX system is described in section .then the result and discussion are taken up in section VI .finally, section VII, conclusion of this work.

II.   HAPS NETWORK ARCHITECTURE

A typical HAP design should seek high reliability, low power consumption, high communication data rates and light payload, thus leading to an architecture that placesmost of the system complexity on the ground segment.

HAPS has the capability of carrying a large variety of wireless communication payloads that can deliver high capacity broadband services to end users. HAPS telecommunication network architecture is shown in Fig.1.In [10]the main reasons for the position of HAPS are: Firstly, these altitudes are above aviation air lines. Secondary, average wind speed is sufficiently low .Third, the platform position allows the HAPS based system to provide better channel conditions because the distance from HAPS is much smaller than that to satellite, since LOS conditions is achievable in almost all the coverage area. On the other hand , decrease distance to HAPS compare to satellite ,significant the path loss decrease, low transmit power for given Quality Of Services(QoS).
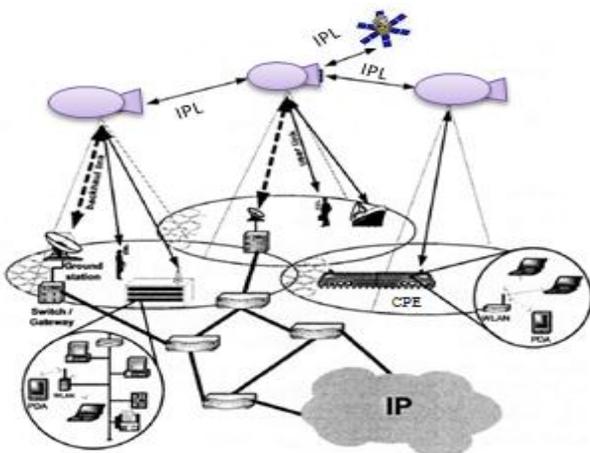

Fig.1. HAP architecture

There are two types of links between the payload and the ground equipment: gateway link and user link Customer-premises equipment (CPE).CPE is any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication channels at the demarcation point and refers to devices such as telephones ,routers,switches,residential gateway (RG). For the user link CPE, the communication is between the platform and the user terminals on the ground in a cellular arrangement permitting substantial frequency.CPE link should also support data streaming from an onboard optical sub-payload. The essential features of Fig.1 include [11]:

(1)At least one CPE is linked to the wider internet via the HAP payload;

(2)One CPE acting as the gateway to the wired internet;

(3) Further users might utilise a Wi-Fi access point whose backhaul is provided via the WiMAX CPE.

Since WiMAX is intended as a point-to multi point WMAN, the base station must be placed on the HAP so as to have in view all the CPEs.

A HAPS gateway link is defined as a radio link between relatively fixed HAP platform and a HAPS gateway station on the ground, located in the Urban Area Coverage (UAC).In[12]There are three main zone under HAPS footprint that depend on the elevation angle of HUTs (HAP User Terminal), UAC, Suburban Area Coverage (SAC), and Rural Area Coverage (RAC).There are three proposed architectures for HAPS communication systems. The difference between them is mainly on network infrastructure involved. They are standalone HAPs system, integrated HAPs terrestrial system, and integrated terrestrial HAPs satellite system[13].WiMAX provides an efficient technologyfor the communication between the flying HAP and the user on the ground. IEEE 806.16 standard focuses mainly on how to provide broadband connection at link layer and physical layer independent on the upper layers [10]. The scenarioin Fig.1includes the User Segment, Sky Segment, and Ground Segment.

• Ground Segment, which includes Network of Servers, Internet and Gateway.

• Sky Segment that includes HAP Networks .

• User Segment that includes WiMAX LAN User Device and Wi-Fi LAN User Device.

III.   TERRESTRIAL WiMAX SYSTEMS

WiMAX is an emerging wireless communication system that can provide broadband access with large-scale

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coverage. WiMAX, considered as a rival to incumbent wired andwireless broadband access technologies for the "last-mile"connections, is the evolving IEEE 802.16 standard. In a WiMAX network, there exist a Base Station (BS) and a number of Subscriber Stations (SS's) similar to other cellular systems. WiMAX is defined to operate in a broad range of frequencies between 2-66 GHz. WiMAX supporting mobility up to vehicular speeds canbe a good candidate to operate in the Terrestrial Component(TC) of a DVB-SH network and to enhance indoor penetration.However, some challenges need to be addressed in the designof such broadcasting transmission system.

WiMAX is aTelecommunication technology that provides fixed and fully mobile internet access. WiMAX uses radio microwave technology to provide wireless internet service to computers and other devices that are equipped with WiMAX compatible chip as in Fig.2.
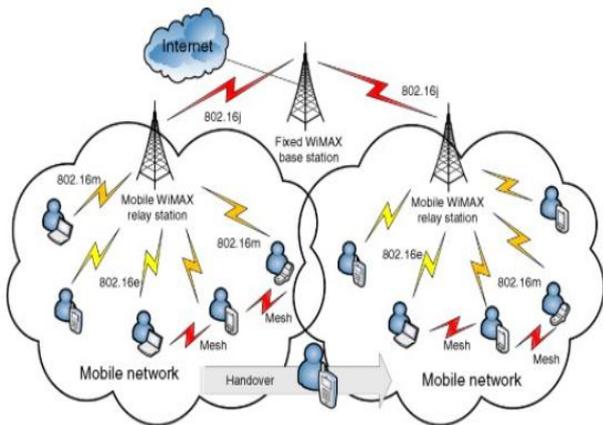

ig.2. WiMAX system deployment scenario

WiMAX technology involves the use of a base station to establish a wireless data communication link, so that it works more or less like cellular network technology, because,this is just as the same way that is required in cellular networks like GSM and UTMS.

WiMAX scenario involves a base station that is normally mounted on top of the building where it can provide optimum coverage. There are two steps that make up the whole communication model in WiMAX:

- Data transmission from WiMAX receiver to the WiMAX base station
- Data transmission from base station to backbone Internet.

The theoretical range of WiMAX is up to 30 miles and achieves data rate up to 75 Mbps. At long range that is greater than 30 miles, the data rate is closer to 1.5Mbps.

IV.   COEXISTENCE OF HAP AND WIMAX

The HAP base station is assumed to be located at an altitude of 17Km above ground with radius of coverage area equal to 30km. In [8] the capability of HAP to serve larger coverage areas using considerably less ground infrastructure than conventional terrestrial systems. WiMAX (IEEE802.16a) has been suggested and widely accepted to provide future broadband services and may operate in unlicensed frequency bands. In same band WiMAX will face coexistence with other systems.

Coexistence means there are more than one system providing services in the same coverage area shared the same frequency band.The system scenario consist of a single HAP base station and terrestrial WiMAX System located inside the HAP coverage area as in Fig.3.The terrestrial base station is located inside the HAP coverage area 10km away from the centre of HAP coverage. The main purpose of this coexistence scenario is to investigate the impact on either an existing HAP or terrestrial WiMAX system when another system using the same frequency band is activated.

The studies[14-16].As in[14], the coexistence between HAPS and TS during the catastrophe situation is possible. In both[14] and [15], the carrier to noise ratio (CNR) and carrier to noise plus interference ratio (CINR) are calculated to find the performance of both terrestrial and HAPS services in order to investigate the possibility of coexistence between the two systems.
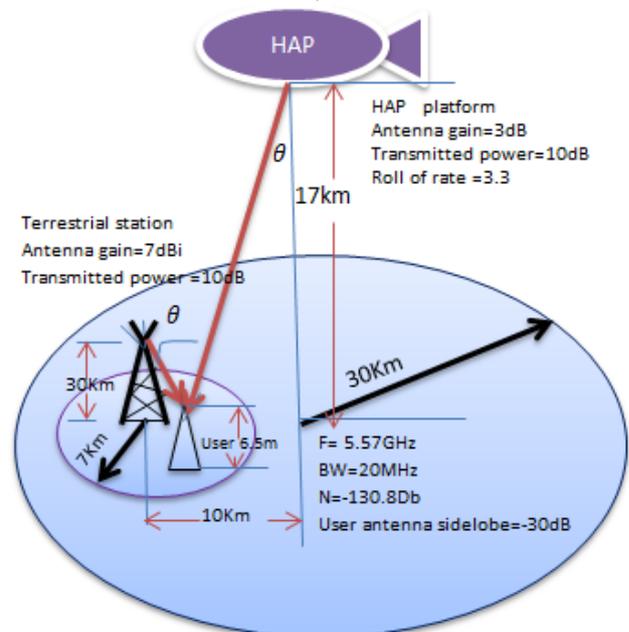

Fig.3. Coexisting HAP and terrestrial base station scenario

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V. PERFORMANCE OF COEXISTENCE

It is novel to provide WiMAX from HAPs but needs to consider its coexistence capability with current terrestrial WiMAX system. WiMAX has been suggested and widely accepted to provide future broadband services and may operate in unlicensed frequency band as well as WiMAX is expected to be a strong competitor to 3rd generation systems.The performance of providing IEEE 802.16 is shown inside the HAP coverage area of Fig. 4. This evaluation scenario consists of a single HAP with a multi- beam antenna payload to serve multiple cells[17, 18]. It is anticipated that providing WiMAX from HAPs to be a competitive and ideal complement to existing terrestrial systems with a greater system capacity and a low complexity deployment[19]. The radius of HAP coverage area and a single HAP cell is typically about 30 km and 8 km, respectively. We assume that cells are hexagonally arranged and clustered in different frequency reuse patterns to cover the HAP service area.

A coexistence model is proposed to evaluate the performancein Fig. 4. We assume the terrestrial WiMAX system uses exactly the same HAP system cellular formation. Hence there are 19 terrestrial base stations considered in the scenario and all the base stations are located in the centre of HAP cells.A user communicating with HAP in an arbitrary HAP cell will be interfered by interference from HAP co-channel antennas and the terrestrial base station in the centre of this arbitrary cell.
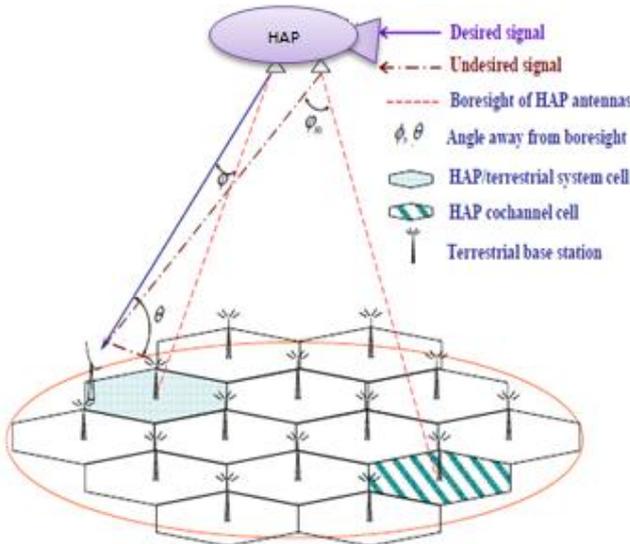

Fig.4. Coexistence model of HAP and terrestrial WiMAX system

The scenario, that a user always receives interference from its nearest base station, could be the worst case since interfering base station is further away from user after adopting any reuse pattern.Fig. 4 shows a plane view of HAP ground cellular deployment. Hereby we assume a single cell radius at 8 km, which is a typical value in terrestrial WiMAX system. It results 19 cells inside the HAP coverage area[10].

VI. METHODOLOGY

The acceptable level of INR is the main parameter utilized in this paper to evaluate the performance of the system. Accordingly, it is the reference to apply the proper adjusted power to reduce the interference level from HAPS to TS. HAPS transmit power must be adjusted in accordance with principles in which the interference is acceptable between the HAPS and the TS. The HAPS is the new technology that will occupy a frequency that is adjacent to the TS, and will cause interference. The first step in the compatibility calculation is to activate the TS and assume there are no HAPS services to cause interfere. After a while, the HAPS is activated and starts to transmit with its highest transmit power. The HAPS activation will cause degradation of performance to the TS; hence the INR is calculated based on three steps [20]; First to calculate the interference from HAPS into TS, second to compute the noise level of the TS receiver, and third we find the INR level of the receiver in order to extract the required adapted to transmit power from HAPS.

The HAP located at altitude of 17km above the ground with coverage radius area equal to30km as in Fig.6.the separation distance between sub-platform point (SSP) on the HAP ground and the terrestrial base station equal to 40km[21].
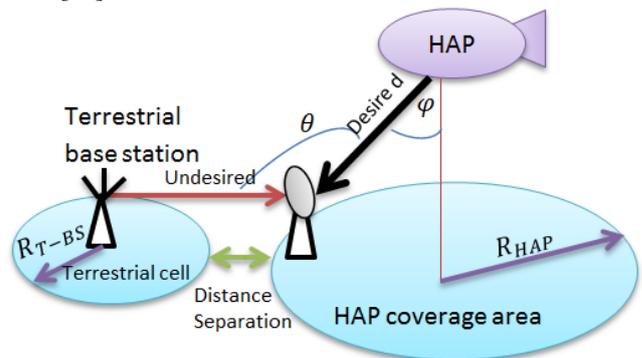

Fig.5.Coexistence model providing WiMAX from HAP

This research paper will focus on the scheme to control parameter such as transmit power to improve efficiency of the coexistence scenario, an Omni-direction antenna is consider for the terrestrial system, which has a small circular coverage area for simplicity. The Omni-direction antenna may not be completely suitable for HAP system. Directional antenna with either elliptical beam can offer better optimized power at cell edges than circular beams. Therefore, a directional antenna is considered for HAP system to radiate power across the desired coverage area at a minimum guaranteed level. As well as the

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directional antenna is considered to be suitable for the users in order to gain the benefit of the high radiating power efficiency.

There are two variable power control schemes called CINR and INR based scheme which getting to improve coexistence performance between HAPS system and terrestrial WiMAX system. The CINR scheme takes the carrier to interference plus noise ratio level as reference. In the other hand, INR, takes interference to noise ratio level as reference, and use to control new activated system transmit power. The INR power control scheme was used to investigate coexistence performance so that the second activated system HAPS can transmit power as long as the INR less than threshold. Threshold requirement is -10dB.The INR can be calculated by (1)

$$INR = I/NF = (P_H A_H(\emptyset) A_U(\theta) PL_T)/N_F \qquad (1)$$

Where N_F is the thermal noise power, P_H is power transmitted of respected base station, $A_H(\emptyset)$ is the transmit gain of base station antenna at an angle $\emptyset$ with respect to its boresight and the receive gain of the user antenna $A_U(\theta)$ at an angle θ away from it bore sight are approximated by a cosine function raised to power roll-off factor n with a flat side lobe level. They are represented in (2) and (3) respectively [21]

$$A_H(\emptyset) = G_H \left(max \left[cos(\emptyset)^{n_H}, s_f \right] \right) \qquad (2)$$

$$A_U(\theta) = G_U \left(max \left[cos(\theta)^{n_U}, s_f \right] \right) \qquad (3)$$

Where G_H and G_U represent the boresight gain of the base station antenna and receive user antenna, and s_f represent a flat side lobe floor in dB. Due to the wide of the beam width of HAP base station antenna and Omni-direction antenna of terrestrial base station, s_f is not considered. n_H and n_U control the rate of power roll-off of the antenna main lobe individually.

Initially, we specify that the -10dB roll-off beam width of HAP antenna is equal to diameter of its coverage area. Therefore more power can be certainly radiated inside the HAP coverage and produce less interference to terrestrial WiMAX system.

PL_T Represent the linear path loss value given by (4) reference by [11]:

$$PL_T = PL_m + \Delta PL_f + \Delta PL_h \qquad (4)$$

Where PL_m is the median path loss in dB.

$$PL_m = A + 10\gamma \log_{10}(d/d_0) + s \qquad (5)$$

Where

A=20

$$\log_{10}(4\pi d_0/\lambda) \qquad (6)$$

Path loss exponent represent by γ.

S represents the shadowing effect. The typical value of standard deviation for s is between 8.2 and 10.6dB.depending on the tree density type /terrain.

ΔPL_f Represent the frequency correction in dB given by (6)

$$\Delta PL_f = 6 \log(f/2000) \qquad (6)$$

Where F is frequency in MHz.

PL_T Covers three common terrain categories described as category A, B and C [11]. So that receive antenna height correction term ΔPL_h (in dB) given by(7)and (8).

$$\Delta PL_h = -10.8 \log(h/2) \text{ types A and B } (7)$$

$$\Delta PL_h = -20 \log(h/2) \text{ type C} \qquad (8)$$

Where h is the receiver antenna height between 2m and 10m.

VII.   RESULT

These graphs are platted using MATLAB in order to show the relationship between power control schemes and distance from HAPs nadir. The most important thing of this study is to mitigate interference to noise ratio by power control management. We consider that there is a single HAP base station with terrestrial base station located inside the coverage of HAP. As in Fig.6 We assumption the distance between terrestrial WiMAX system and HAP is 10km .As well as the terrestrial WiMAX system used Rayleigh channel to transmit power to the user. Therefore it is suitable for the propagation of the terrestrial WiMAX system and HAP system is in line of sight. All of results have done by MATLAB.

If the INR is greater than -10dB, power control is needed to adjust the power at terrestrial WiMAX. Meanwhile for the INR that is lower than -10dB the transmit power from terrestrial is not changed.

Vary the modulation scheme of HAP from BPSK modulation to 64QAM modulation scheme. Therefore the terrestrial WiMAX and HAP can work effectively in coexistence coverage.

A. BPSK modulation for HAP

In this case, the power transmit from the HAP is lower than power transmit from the terrestrial WiMAX such as power transmit from WiMAX is 7.5284 but the power transmit from HAP is 4.5503.Therefore no need to adjust terrestrial power, the signal to noise ratio isn't changed. That because using of BPSK modulation on HAP and the interference to noise ratio is lower than threshold.

In Fig.7 shows the interference to noise ratio decrease when the user is far away from HAP.
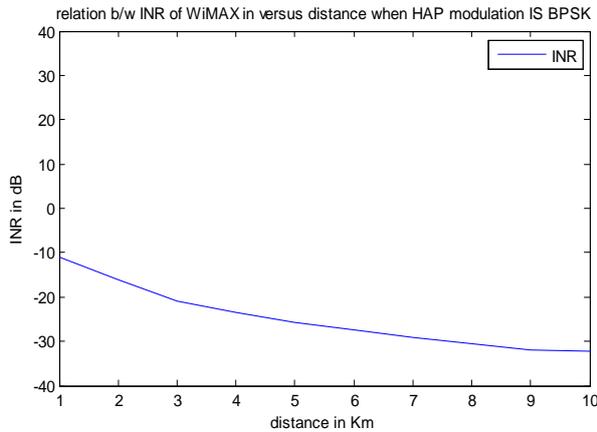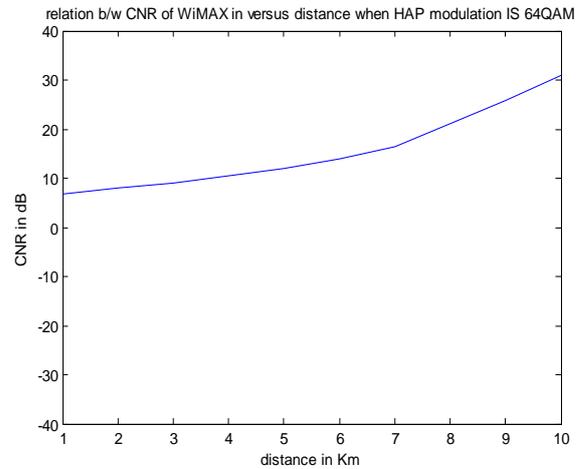
Fig.6. BPSK INR various distances

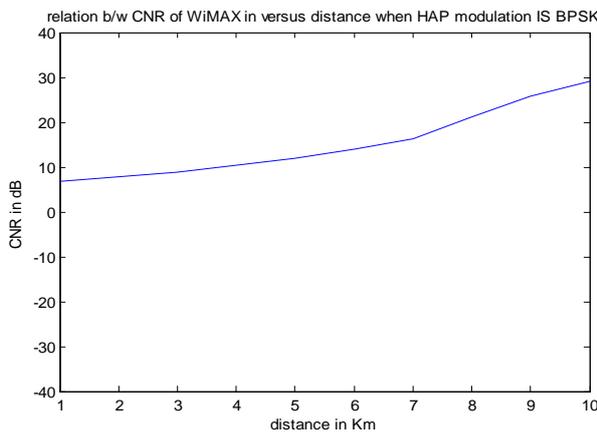In Fig.7shows that carrier to noise ratio increases .this is because the user getting nearer to the terrestrial WiMAX.

Fig.7.BPSK CNR for various distances

B. 64QAM Modulation for HAP

In this case the transmit power from HAP is higher than transmit power from terrestrial WiMAX 7.5793,23.7982 respectively. Therefore, the interference to noise ratio is above of the threshold, the carrier to noise ratio changed ,and the terrestrial base station of WiMAX needs to increase its transmit power for coexistence performance of these systems.

In Fig.8 shows the relationship between carrier to noise ratio of HAP with various distance when the modulation scheme is 64QAM.The carrier to noise ratio increases when the distance between HAP and user increase as shown in Fig.8.

In Fig.9 shows the relationship between interference to noise ratio of HAP with various distance when the modulation scheme is 64QAM.

As shown in Fig.9, the interference to noise ratio decrease when the distance between HAP and terrestrial WiMAX is increase.

Fig.8. 64QAM CNR versus distance

When the user is far away from HAP is 7km, the interference decrease drastically because the user start to go out of the HAP coverage and transmit power of terrestrial system is getting higher.
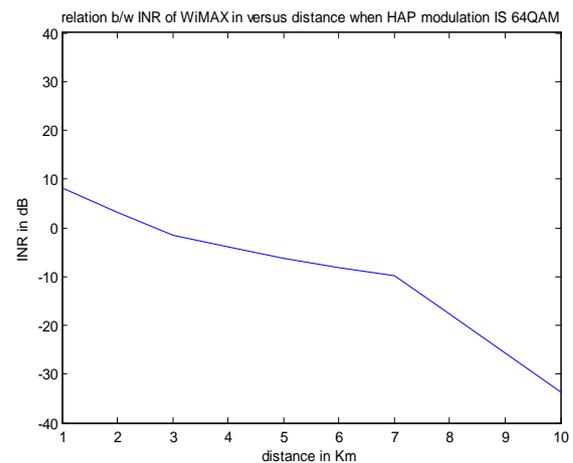

Fig.9. 64QAM INR versus distance

VIII.   CONCLUSION

In this paper we have looked at the coexistence performance and capability of HAP and terrestrial WiMAX systems. Coexistence performance was evaluated in fixed separation distance case between HAP and terrestrial base station is 10km, as well as the result show that the hap and terrestrial system share the same frequency band.The interference from HAP system to terrestrial WiMAX decrease and both system can work effectively because the transmit power from terrestrial WiMAX can be adjusted to provide high power.

The result show that In case of using BPSK modulation, the transmit power from HAP is lower than transmit power from terrestrial. So that interference to noise ratio

below the threshold as well as transmit power from terrestrial system don't require adjusting.

In the other case (64QAM), power control scheme is require to adjust because the transmit power from HAP is great. When the power on terrestrial WiMAX can be increase, then the interference to noise ratio will decrease. Therefore the coexistence will be better.

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