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Measurements to design a coverage area by using high altitude platform systems

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ABSTRACT

This paper proposes the principles of how to design UMTS coverage area for Baghdad city the capital of Iraq country as a case study that occupy area about 204.2 km², by using one of the new technology for providing two wireless bands which are narrowband and broadband communication services as well as for broadcasting services issues with either airships or airplanes techniques which is named HAPs, Viewed from its altitude, HAPs floats within the stratosphere layer in the airspace, positioned between satellite and terrestrial platforms. This study also cosidered the affect of interference with the available broadband technology. It will start with brief introduction for HAPS with its advantages, comparison between HAPS system and other services and specify requirements for design. Such as, enumerate and find the center of coverage area to calculate the coordinates. Then, design the coverage area for the city, and find the radius, elevation angle, and the position of earth stations which will connect HAPS with other networks and all other services location depending on latitude and longitude, finally the reduction of interference technique.

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1. INTRODUCTION

HAP is defined as an airship or aircraft which commonly positioned at 20-25 km altitude in the tropospheric layer. This altitude makes the airship useful in wireless communications system and permits the delivery obvious advantage when compare it to satellites and terrestrial system. HAP is proposed to provide two wireless bands which are narrow band and broadband communication services (internet, cellular services) with both types (airships and aircrafts) [1]. as well as HAPs has many benefits such as, low propagation delay, easy and incremental deployment, flexibility, easy to configure, high elevation angles, broadcast/multicast capability, broadband capability, ability to move around in emergency situations [2]. The main constrains for the HAPS platform system are power consumption and availablity for the platform payload, spectrum allocation, stability and the movement of the platform, maximum power that trasmitted from HAPS transvers, space available on the platform, payload mass constraints, link and platform availability during rainy conditions and the clear sky, the ease of refueling as well as providing local and regional coverage [3]. By the comparisons between HAPS, terrestrial and satellite systems the platform position allows the HAPs-based system to provide better channel conditions than satellite. A condition of line of sight (LOS) is achievable in almost all the coverage area (UAC, SAC and RAC), hence less shadowing areas than terrestrial system [2]. Therefore, HAPs require much less transmission power for a given quality of services (QOS) [4]. Essentially, HAPs perform capably on tasks that are presently at this time handled using both of terrestrial and satellite systems. Broadcast services ,weather monitoring, surveillance and many other application are used by HAPs Technology [5].

HAP system are combined of platforms and gateways, but in the real implemintation there is a limitation in the number of same-frequency gateway links [1]. HAPS network (HAPSN) and its connectins with FSS networks has been an issue in recent few years. Fundamentally, HAPS gateway links are channelized in the combination of frequency ranges which FSS links occupy, creating of severe interference levels, particularly at high arc of FSS Earth station angel of elevation [6]. This paper comprises several sections started with general idea about HAPS technique. While the followed section discusses the HAPs systems segments. Section three present the caparisons between the HAPs system with the other existing telecommunication system in Baghdad, while the fourth challenges section presents the area the covered by HAPS finally the result is calculated by using equation to design new telecommunication system to cover Baghdad city.

2. LETERTURE

2.1. Component of haps communication systems

A new technology (HAPs) communication system consist of gound segment and atmosphere segment [7]. The main sections of atmosphere segment consist of the platform and the onboard communications payload. Where Platform, is a flying aircraft comes in different form started with the earliest aerial platform were balloon then Airship HAPs, Airplane HAPs and UAV (Unmanned Aerial Vehicle) forceful circle. The second segment is represented in energy supply it chosen from of energy source is solar power,the proposed design of HAPS are designed for large surfaces which is useful for lining solar panels [7]. On the other hand, the communication payload which is the third part is consist of phased array antennas transmit or a reflector of multi beam light-Wight with gorund station for swithching purpose. the processes of control receiving, switching, multiplexing, and transmitting functions are controls by large processors associated with the ground switching station [8]. Antenna subsystem is one of the main sections of a HAPS communications payload, depending on the selection of reuse factor and multiple access, the HAPS technology is critical to co-channel interference [9].

2.2. Advantages of haps over existing terrestrial and satellite technologies

The new technology of HAPs communications services from will lead to many possible applications. HAPs offer extra characteristics than terrestrial and/or satellite architectures do [10, 7]. The one of drawback of terrestrial system is the long-range terrestrial links are strongly affected by rain attenuation through high coverage area while the new technology of high-altitude platform communication system proposes large coverage area compared to terrestrial system with better path-loss characteristics in all weather fluctuations. Other improvement that offered by HAPs is the Cost of deploying HAPs platform is considered cheaper than satellites stations and terrestrial (within the similar coverage space), In one hand the satellite system is take high budget in installation and lunching while the terrestrial the deployment of its network system is expensive [11]. In the other hand HAPs has more advantage in propagation delay associate to satellites system [12]. And it considers ideal for multimedia services, multi-cast, and broadcast. In addition due to ITU-R recommendation the factor of elevation angles should be high to offer clear line of sight signal paths and low propagation delay [6]. The combinations of the gains of both communication system satellite and terrestrial and avoid all the drawbcks of both of them that make the high altitude platforms (HAPs) is considerable as a unique alternative in wireless communication [11, 13]. Due to all benefits that offered by a new communication/telecommunication technology (HAPs) as a promising system that an effective balance to the current communication system.

2.3. Haps network architecture

High capacity broadband telecommunication network need a powerful network infrastructure that's come where three communication technology incorporate together to overcome the weakness of each other [12]. High capacity broadband that presented by the exit wireless communication technology HAPs capability of carrying high capacity delivery of broadband services to end users [14]. The architecture of high-level HAPS telecommunication network consist of two links between payload and ground equipment: First one is defined as a gateway link which is a radio link placed between HAPS gateway station on the earth and HAPs platform aircraft and the other type is user link which is the link sits between the HAPs atmosphere segment and the user terminals on the ground segment. Three recommended architectures are designed for HAPS communication system [15], stand-alone HAP system which use a fiber optic network or satellite as a backbone link on the applications like weather monitoring, and disaster surveillance. The integrated terrestrial-HAP-terrestrial system: this type of HAP network propose to encourage a high quality of service through the connection of terrestrial system network across a gateway. while the combined terrestrial-HAP-satellite system is considerd as a last category that can encourage a high (QoF) quality of service by taking the benefits of important features of both HAPs and satellite communication systems [4].

2.4. Haps spectrum allocation

By using the similar or neighboring frequency bands between the HAPs systems on the apportionment of strict conditions of a frequency bands and non-interference [16]. One of the influential parameter that has a big role to avoid the interfeference the HAPs signals with the other existing communication and telecommunication system is the using exact and accurate frequency. Interference mitigation techniques that recommended by ITU-R are involved to make the frequency would be sharing between the HAPS system and Narrowband and broadband services [17]. In this study we assume the frequency band for all services are same.

2.5. Haps coverage

In Depending on elevation angle and the altitude of platform determine the coverage area of HAPS, due to previous study one HAPS has the ablility of delivering about 400km radius of ground area which is corresponding to 258 tower of ground terrestrial coverage [18]. By research done in 2017 the capacity of single HAPS is preferable than using multiple HAPS system because more than one HAPS in overlapped region experience interference from users [19]. Further on the type of antenna like a multi beam antenna used by single HAPs with the high and accurate frequency reuse efficiency aimed to cover many subscriber grounds [20]. To get better channel condition 17-25 km altitudes of HAPS is operating in the stratosphere as recommended in ITU-R, this altitude of HAPs let the HAPs-based system to present better channel conditions. Table 1 clarify that the best altitude of HAPs is 22km which is the preferable position of HAPs coverage where the relation between the minimum elevation and the coverage diameter.

Although additional identification of HAPs frequency band have been assigned at 28 GHz and 31 GHz, the geographic are defined the selection between those two frequincies. Furthermore, even though in the next WRC-19 proposed additional global HAPs spectrum candidates, and other services (mobile and satellite services) have been introduced within the same frequency ranges [19]. The other factor that affected on coverage area of HAPS and the spot beams within limited area is the antenna array which prepared to coordinate the desire for capacity within any particular coverage area [15]. In this study we use HAPS system to provide services to region extending for mobile cell phone coverage or steady wireless from (UA) urban area with high density to (RA) rural areas with low density [21]. As on exisit terrestrial system the user terminal of HAPs will be propsed to share the similar radio interface, thus a single handset will drive with two types of towers which are the traditional terrestrial towers and HAPS. Therefore this will support worldwide roaming and regional with a unique handset.

Table 1. Minimum elevation, coverage and maximum communication distanc [22]

Minimum elevation (°)	Diameter of coverage (Km)	Maximum communication distance (Km)
0	1056	529
2	702	352
5	420	212
10	336	120
15	160	83
30	30	44

3. RESULT

3.1. Location

According to Baghdad Map, and after studying area. The center of coverage area location's coordinates of HAPS will be as shown in Figure 1 (lat.: 33.3191° N, long: 44.3920° E). Altitude of HAPS: as it’s known, the rang height of HAPs platform is between 17km and 22km. So, we will be supposed to put the station on an altitude of 21km as clarify in Figure 2.

3.2. Foot print

The whole area of Baghdad whose estimated to (204.2 km²) as shown in Figure 1 and with the taking into consideration the geographical terrain which is characterized as a plain land and high population density due to it’s a city capital of Iraq. Further more in the condition of rainfall is about (0.04 in) in summer season while in winter the average approximately (5.91 in) all those factors has affected in determining the position and quality of signals of the HAPs.

Figure 1. Baghdad map

3.3. Elevation angle

Can be for first base station is 33, and for second base station is 54. Distance: by using the previous elevation angles we can calculate the distance from:

$$\mathbf{d1} = \frac{\textbf{Altitude}}{\tan(\theta_1)} = \frac{\textbf{21 km}}{\tan(54)} = \mathbf{15.257km}$$

$$d2 = \frac{Altitude}{tan(\theta_2)} = \frac{21\ km}{tan(33)} = \mathbf{32.337}\boldsymbol{km}$$

in this assignment we assume that all services (FSS and FS) have same frequency. Also, we assume the place of first FS ground station at:

Latitude: 33.189 N **Longitude:** 43.935 E
And for second FS ground station is:
Latitude:33.319 N **Longitude**: 43.835 E
And for FSS ground station is:
Latitude: 33.489 N **Longitude**: 43.945 E
Depending on that and we assume the HAPS will play at the center of Baghdad at:
Latitude:33.319 N **Longitude**:44.392E

We decide to put HAPS ground stations at:

Latitude :33.319 N Longitude:44.459 E
At (ϴ=54 degree)
Latitude :33.319 N Longitude:44.549E
At (ϴ=33 degree)

In based on design, enough distance regarding to the total area of the Baghdad city then also the enough distance between FS and FSS, and my scenario of that like shown in Figure 2. Depending on this design we reduce the interferences between HAPS system and other services. By using different elevation angle, the worst interference occure when HAPs's elevation angle toward FWA station is equivalent to elevation angle from HAPS to HAPGS [23]. By using the mitigation techniques deal with ITU-R F.1607 the minimizing the interference between HAPS and other systems is by:

– Increasing minimum operational elevation angle: The angle located between FS and HAPs ground station indentify as a elevation angel [24], in this study we already use fixed two elevation angle (33 degree and 54 degree), therefore we did not follow this type of mitigation.
– Improvement of radiation patterns of antennas. This technique is giving small amount of interference according to low elevation angle of special antenna gain to a particular spot beam and utilize elliptical beam patterns. the small elevation angle with higher gain because of the beam near the border of coverage service, small side lobe coverage service beam near the center instead of do narrower beamwidth [25].
– Dynamic channel assignment, this type of technique use self-controlled manner when communication systems stimulate on a demand-assignment fundamental which is efficient for sharing with other services [14].
– Automatic transmitting power control (ATPC): The principle of ATPC scheme is to control the output power and receiving power in the monitoring the weather situation,the ATPC amplify the power in a rain condition and decrease the power during clear sky situation [11, 18].
– Shielding effect by HAPS airship envelope: The metal coating of HAPS airship envelop has be affect to characteristics of antennas back-lobe and side-lobe beam on board the HAPS airship. Furthermore the calculation of Interference between satellite space segment and HAPS airship is reduced [5].

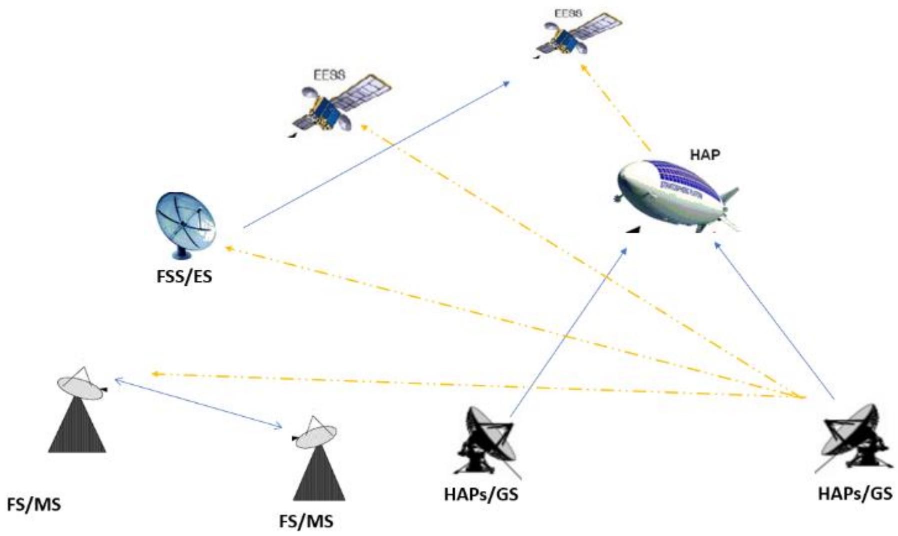

Figure 2. Scenario of Interference situation including HAPS, FSS, FS

4. CONCLUSION

In this work, we tried to design of narrow band and broadband of communication services for Baghdad city by release one HAPs Platform connecting with two earth stations to make the network. The geographical area is smooth with some heights. The weather is always clear, due to those charecterstics the expected availability will be 99.99%, and this network will cover specific area of Baghdad city and services like terrestrial and satellite it is already existing there but with lower cost, better path-loss characteristics, and minimum propagation delay according to the altitude, therefore by putting HAPS that cause interference, this paper, shows the ways to decrease the interference especially by using suitable type of antenna radiation pattern and other recommende mitigation techniques that appropriate chosen area.

REFERENCES

[1] D. Grace, M. H. Capstick, M. Mohorcic, J. Horwath, M. B. Pallavicini, and M. Fitch, “Integrating users into the wider broadband network via high altitude platforms,” *IEEE Wirel. Commun.*, vol. 12, no. 5, pp. 98-105, 2005.
[2] K. R. Tariq, M. B. Majed, and Z. A. Hamid, “Design of Wireless Communication System to Cover Specific Area by Using HAPS,” *univesity Hum. Dev.*, no. April, pp. 361-357, 2015.

[3] Itu-r, "Spectrum needs of high-altitude platform stations broadband links operating in the fixed service F Series Fixed service," *International Telecommunication Union*, 2018.

[4] J. L. Cuevas-Ruiz, A. Aragón-Zavala, and B. Bautista-León, "Co-channel interference for terrestrial and HAPS systems in a cellular structure," *CERMA 2009-Electron. Robot. Automot. Mech. Conf.*, pp. 50-54, 2009.

[5] Z. Yang and A. Mohammed, "Wireless communications from high altitude platforms: Applications, deployment and development," *Int. Conf. Commun. Technol. Proceedings, ICCT*, pp. 1476-1479, 2010.

[6] S. Karapantazis and F. N. Pavlidou, "Broadband communications via high-altitude platforms: A survey," *IEEE Commun. Surv. Tutorials*, vol. 7, no. 1, pp. 2-31, 2005.

[7] A. Ayoola and O. Oladipo, "Stratospheric Propagation and HAPs Channel Modeling," This thesis is presented as part of the Degree of Master of Science in Electrical Engineering with emphasis on Telecommunications/Signal Processing, 2007. [Online]. Available: http://www.diva-portal.org/smash/get/diva2:833457/FULLTEXT01.pdf

[8] D. Avagnina, F. Dovis, A. Ghiglione, and P. Mulassano, "Wireless networks based on high-altitude platforms for the provision of integrated navigation/communication services," *IEEE Commun. Mag.*, vol. 40, no. 2, pp. 119-125, 2002.

[9] Iskandar and A. Manaor, "Interference analysis of border area technology: HAPS and GEO satellite in EXT-C band," *Proc.-ICWT 2017 3rd Int. Conf. Wirel. Telemat. 2017*, vol. 2017-July, no. 10, pp. 118-122, 2018.

[10] T. C. Tozer and D. Grace, "H igh-altitude platforms for wireless communications," *Electronics &Communications Engineering Journal*, vol. 13, no. 3, pp. 127-137, 2001.

[11] A. Asadi, Q. Wang, and V. Mancuso, "A survey on device-to-device communication in cellular networks," *IEEE Commun. Surv. Tutorials*, vol. 16, no. 4, pp. 1801-1819, 2014.

[12] ITU, "Interference mitigation techniques for use by high altitude platform stations in the 27.5-28.35 GHz and 31.0-31.3 GHz bands," *ITU*, Geneva, p. 02, 2010.

[13] N. A. Mohd Aris, L. Luini, J. Din, and H. Y. Lam, "1-minute integrated rain rate statistics estimated from Tropical Rainfall Measuring Mission data," *IEEE Antennas Wirel. Propag. Lett.*, vol. 12, pp. 132-135, 2013.

[14] A. Mohammed and Z. Yang, "Broadband Communications and Applications from High Altitude Platforms," *Int. J. Recent Trends Eng.*, vol. 1, no. 3, pp. 239-243, 2009.

[15] ITU, "Preferred characteristics of systems in the fixed service using high altitude platforms operating in the bands 47.2-47.5 GHz and 47.9-48.2 GHz.," *ITU-R*, Geneva, 2010.

[16] N. S. Rajput, "Interference Environment between High Altitude Platform Station and Fixed Wireless Access Stations," *Int. J. Eng. Res. Appl.*, vol. 2, no. 2, pp. 1508-1513, 2012.

[17] TATT (Telecommunications Authority of Trinidad and Tobago), "Spectrum Plan for the Accommodation of Public Mobile Telecommunications Services," no. July, 2013.

[18] N. Architecture, O. A. Angle, and E. Angle, "Methodology for Coexistence of High Altitude Platform Ground Stations and Radio Relay Stations with Reduced Interference," *International Journal of Scientific & Engineering Research*, vol. 3, no. 5, pp. 1-7, 2012.

[19] Iskandar, S. Gratsia, and M. E. Ernawan, "LTE uplink cellular capacity analysis in a High Altitude Platforms (HAPS) communication," *Proceeding 2017 11th Int. Conf. Telecommun. Syst. Serv. Appl. TSSA 2017*, vol. 2018-January, no. October, pp. 1-5, 2018.

[20] Zulfatman, M. F. Rahmat, A. R. Husain, R. Ghazali, and S. M. Rozali, "Smooth control action of sliding mode for a class of electro-hydraulic actuator," *2011 4th Int. Conf. Mechatronics Integr. Eng. Ind. Soc. Dev. ICOM'11-Conf. Proc.*, no. May, pp. 17-19, 2011.

[21] A. Aragón-Zavala, J. L. Cuevas-Ruíz, and J. A. Delgado-Penín, "High-Altitude Platforms for Wireless Communications," *High-Altitude Platforms Wirel. Commun.*, no. July, pp. 1-241, 2008.

[22] M. Guan, Q. Guo, and X. Gu, "Performance evaluation of coverage and wireless link characteristic for HAPS communication," *Dianbo Kexue Xuebao/Chinese J. Radio Sci.*, vol. 27, no. 4, pp. 832-839, 2012.

[23] V. F. Milas and P. Constantinou, "Interference environment between High Altitude Platform Networks (HAPN), Geostationary (GEO) satellite and wireless terrestrial systems," *Wirel. Pers. Commun.*, vol. 32, no. 3-4, pp. 257-274, 2005.

[24] M. Cardenas-Juarez and M. Ghogho, "Spectrum sensing and throughput trade-off in cognitive radio under outage constraints over Nakagami fading," *IEEE Commun. Lett.*, vol. 15, no. 10, pp. 1110-1113, 2011.

[25] J. Thornton, D. A. J. Pearce, D. Grace, M. Oodo, K. Katzis, and T. C. Tozer, "Effect of antenna beam pattern and layout on cellular performance in high altitude platform communications," *Wirel. Pers. Commun.*, vol. 35, no. 1-2, pp. 35-51, 2005.