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COGNITIVE ARCHITECTURE OF THE 5G SYSTEM BASED ON THE INTERACTION OF TERRESTRIAL AND SATELLITE COMPONENTS

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Когнітивна архітектура системи 5G на базі взаємодії наземної та супутникової складових

На сьогоднішній день спостерігається швидке поширення мобільних додатків, стрімке збільшення трафіку бездротової передачі даних та посилення інтеграції бездротового зв'язку у багатьох аспектах повсякденного життя. Це викликає необхідність розгортання мобільних мереж, які можуть підтримувати експоненціально зростаючий трафік бездротової передачі даних. У роботі пропонується гібридна супутниково - наземна мережа, яка забезпечує більш високу швидкість передачі даних та менше енергоспоживання порівняно з сучасними стільниковими архітектурами LTE та LTE-Advanced.

Nowadays, there has been a rapid expansion of mobile applications, a rapid increase in wireless data traffic and increased integration of wireless in many aspects of everyday life. This calls for the deployment of mobile networks that can support exponentially growing wireless data traffic. The hybrid satellite - terrestrial network, which provides higher data rates and lower power consumption compared to the current LTE and LTE - Advanced cellular architecture, is proposed in the work.

The increasing demand for data in mobile communication networks has resulted in the need for developing sufficient and advanced network infrastructures to support higher capacity and data rate. The forecasts in [1] shows that by 2018 the mobile data traffic will be 6.3 times higher than it was in 2013. In addition to this, the global CO2 emissions of the mobile communications sector are expected to rise to 178 Megatons in 2020 [2]. The main concept under investigation in this paper is the separation of the control (C)-plane and the user (U)-plane in the Radio Access Network (RAN). The C-plane provides ubiquitous coverage via the macro cells at low frequency band. On the other hand, the U-plane functionality is provided by the small/data cells at a higher frequency band, such as 3.5, 5, 10 GHz, where new licensed spectrum is expected to be available for future use. The use of such bands for small cells can lead to a significant increase in capacity, since they can offer bandwidth up to 100 MHz [3]. The C-plane and U-plane are not necessarily handled by the same node and are separated. Consequently, this gives the network operators more flexibility, since the C-plane (control/macro cells) manages UEs connectivity and mobility [4].

In this paper, a hybrid satellite terrestrial network architecture is presented, where a satellite is deployed to provide C-plane functionality, while femtocells are deployed to provide U-plane functionality.

The International Telecommunication Union (ITU) defines a “hybrid satellite terrestrial system” as the one that employs satellite and terrestrial components that are interconnected, but operate independently of each other [5]. In systems like this, terrestial and satellite components can use different frequency bands and use separated mannagment systems. An illustration of the proposed Hybrid network is shown in Figure 1.

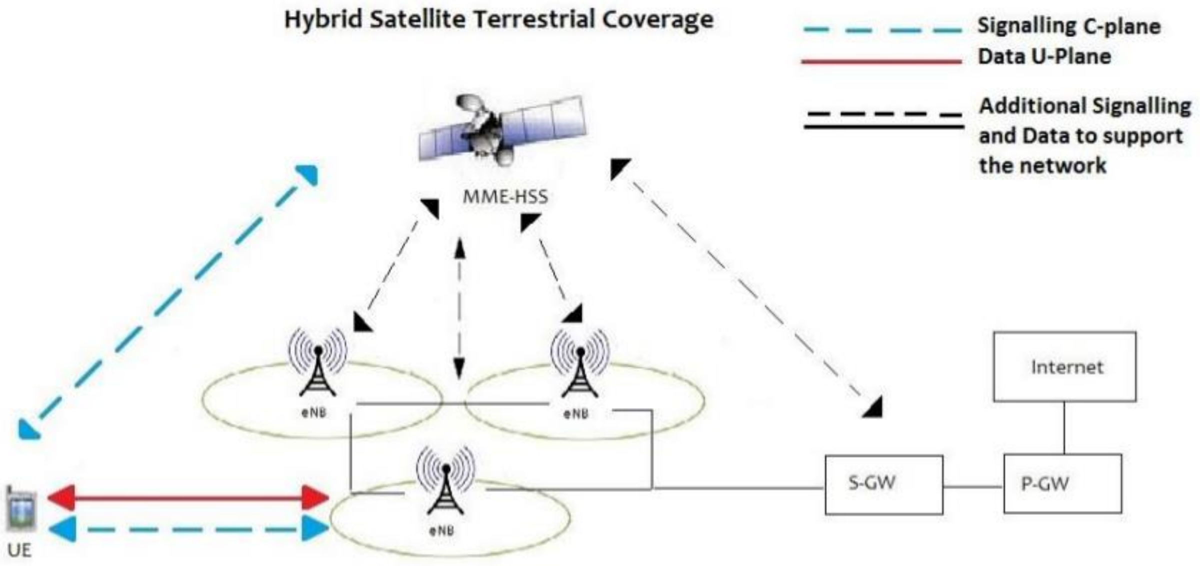

Fig. 1. Hybrid satellite terrestial system architecture

The satellite can provide a coverage of the whole terrestial network and it is also used as a Home Subscribers Server (HSS). It means that satellite caries information about the subscribers. Satellite can also communicate with a backbone network, like Serving Gateway (S-GW) and can be used as a Mobility Managment Entity (MME), in other words it can be responsible for mobility managment of users.

The terrestial part consists of femtocells/eNBs that are connected via fibre optic network. Fibre optic connection can also be used to connect eNBs with a backbone network. This type of connection minimises loses and provides fast data transfer among femtocells. The reason for having two paths for the C-plane communication is that for some User Equipment (UE) activities, signalling from both the U-plane (eNB) and the C-plane (satellite) are required for successful operation. For example, power coordination and handover procedures require accurate measurement, which cannot be provided through the satellite channel due to high latency.

The main advantage of separating the C-plane from the U-plane in cellular networks is the ability to replace part of the resources reserved for the signalling of the U-plane, with actual data. In general, the complete separation of the two planes is not possible, due to the fact that some of the C-plane functionalities have to be in the U-plane to support the reliability of the actual data transmission. But, in general, the main idea is to give the satellite component all the controlling procedures and give data transmission procedures to the terrestial component.

In order to provide the efficiency of the perfomance of this architecture there is goin to be a simulation in Matlab where two main equations are going to be used:(1) that is used to be Friis equation considering Gt =10dB and Gr =1.5dB as the typical antenna gains of the transmitter and receiver respectively, Pr = -80 dBm for the minimum receive power, λ the wavelength, and d the distance of the satellite orbit from the earth user (36,000 km for GEO and 800 km for LEO) and (2) that is used to be Shannon's equation where B = 20 MHz the available bandwidth per cell, No = -174 dBm/Hz the noise spectral density and Io the interference produced by the neighboring active eNBs assuming that the requirement of having and existing line-of-sight (LOS) path between the UE and the satellite is satisfied.

$$P_t = \frac{P_r}{G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2} \quad (1) \qquad C_{per\_user} = B \log_2 (1 + \frac{P_r}{N_0 B + I_0}) \quad (2)$$

The performance requirements for a mobile technology to be considered as 4G or beyond 4G, must comply with the requirements of the International Mobile Telecommunication (IMT) Advanced standard. These requirements suggest that the average spectral efficiency must be greater than 2.2 bits/s/Hz, and also the C-plane latency for the transmission from RRC_IDLE to RRC_CONNECTED state, must be less than 100msec [6].

As a result, the proposed Hybrid Satellite Terrestrial architecture should give encouraging results towards its consideration for possible deployment in future mobile networks. The hybrid architecture, compared with state of the art technologies, should also give the highest capacity per square meter and the lowest power consumption per square meter for wireless transmission purposes. Moreover, the technical specifications of the proposed architecture should comply with the 4G standards.

References

1. W. Rupert, (21 October 2013). Mobile data will grow 6.3 times between 2013 and 2018 and growth will be strongest outside Europe and North America. [Online] Available: http://www.analysysmason.com/AboutUs/News/Insight/Mobile-data-Oct2013/ [Accessed: 18 August 2014].
2. M. Gruber, O. Blume, D. Ferling, D. Zeller, M.A Imran, E.C. Strinati.: EARTH—Energy Aware Radio and Network Technologies. IEEE International Symposium on Personal, Indoor and Mobile Radio Communications , pp. 1-5, Sept. 2009.
3. H. Ishii, Y. Kishiyama, H. Takahashi.: A novel architecture for LTE-B :C-plane/U-plane split and Phantom Cell concept. IEEE Globecom Workshops (GC Wkshps), pp.624-630, Dec. 2012.
4. A. Zakrzewska, D. Lopez-Perez, S. Kucera, H. Claussen.: Dual connectivity in LTE HetNets with split control- and user-plane. IEEE Globecom Workshops, pp.391 396, Dec. 2013.
5. K. Sooyoung, K. Heewook, A. Do Seob.: A Cooperative Transmit Diversity Scheme for Mobile Satellite Broadcasting Systems. Advanced Satellite Mobile Systems, ASMS, pp.72-75, Aug. 2008.
6. ITU Radiocommunication Sector (ITU-R).: ITU global standard for international mobile telecommunications "IMT-Advanced". [Online] Available: http://www.itu.int/ITU-R/index.asp?category=information&rlink=imt-advanced&lang=en.