

A Moving Cell Bearer Management Architecture for LTE-Advanced System

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Abstract— Mobile data traffic has been predicted to grow exponentially in the next several years due to recent increased penetration of mobile devices running a vast array of mobile applications. Moving cell is a concept to further evolve fixed small cell technology for the next generation wireless system which is solved the rapid increase of traffic. It provides a continuous connection to the mobile network and moves around its connection network along to the user. A moving cell in Long Term Evolution-Advanced (LTE-A) cellular network confers a flexibility to the system and allows for a more enhanced mobility management, and supports heterogeneous radio access technologies simultaneously. It can establish the new bearer type for heterogeneous radio access technologies and improve the quality of service for user and to provide high data rate, low delay, and low power consumption for user mobile equipment. In this paper, we propose a moving cell bearer control mechanism and the architecture of moving cell supported by a LTE-A system for 5 Generation. The cellular network needs to establish a new type of the Evolved Packet System (EPS) bearer for WiFi radio bearer of the moving cell. We describe the entities of this architecture, the protocol stack and describe how user bearers setup.

Keywords— Moving cell, LTE-A

I. INTRODUCTION

The 5G Era network will need flexible and powerful nodes at the edge to offload the traffic from the core network, to manage data flows efficiently by dynamically adjusting network resources to ensure high quality of experience (QoE) for each application flow, and to process the raw information coming from the multitude of sensors/Internet of Things device [1].

Fueled by the increasing popularity of handheld mobile devices with powerful data processing capabilities, the wireless industry is witnessing an avalanche of mobile traffic. Indeed, the amount of data produced by smartphones, tablets, PDAs, and new types of mobile computing devices has recently been doubling every year with this trend very likely to continue over the following decade. This unprecedented escalation has imposed significant challenges on the design of existing wireless networks. Subsequently, we outline the state of the art in cellular design, which clearly shows that these trends cannot be met with legacy approaches. We then explain the rationale of integrating WiFi with legacy cellular systems,

before discussing trends beyond the state of the art, along with our specific contributions in the field [2].

Today, the macro cell network capacity cannot continue to scale any further. The expensive tower-mounted macro cells generally demand high installation, maintenance, and backhauling costs as well as elaborate site planning, and thus suffer from the lack of available sites.

As 5G-centric research is taking shape, it becomes apparent that a single (new) radio technology will not be able to satisfy all the associated performance requirements and characteristics [3]. However, ultra-dense HetNets, enabling efficient reuse of spectrum across a certain area of interest [4], [5], are very likely to become the only viable solution on the road to 1000x capacity in a less than ten year time frame [6].

A transformation of mobile user experience requires revolutionary changes in both network infrastructure and device architecture, where the user equipment (UE) is jointly optimized with the surrounding network context [7]. Many believe that the only feasible solution to mitigate the increasing disproportion between the desired QoS and the limited wireless resources is by deploying higher densities of femto- and picocells in current cellular architecture. Due to shorter radio links, smaller cells provide higher data rates and require less energy for uplink transmission, especially in urban environments.

More importantly, licensed spectrum continues to be scarce and expensive, whereas the traditional methods to improve its efficient use are approaching their theoretical limits. Even when additional spectrum is allocated, these new frequencies are likely to remain fragmented and could require diverse transmission techniques. Consequently, there is a pressing demand to leverage additional capacity across multiple radio access technologies (RATs) [8].

In this paper, we investigate the concept of user centric moving cell which is an enhanced LTE-A system based on network architecture. The user centric moving cell can be deployed in public transportation vehicles or private cars that form its own cell inside vehicles to serve vehicular and mobile user equipment such as smart-phones, Machine Type Communication (MTC) devices.

The remaining of this paper is organized as follows. Section II presents some related work. Section III introduces our proposed architecture for the moving cell. Section IV shows design of moving cell bearer control. The proposed control

architecture and call flow are presented in Section V. Finally Section VI provides the conclusions and some further research directions.

II. RELATED WORK

A moving network describes a group of mobile nodes or terminals (e.g. vehicles with advanced communication and networking capabilities) that form a “moving network” which enables the communication between those nodes. A moving network is not only restricted to networks within a vehicle, but is also extended to networks between and outside vehicles. Moreover, the concept of nomadic network nodes allows for a flexible deployment of networks depending on traffic, service and coverage demands. A nomadic node describes a network node that provides relay-like communication capabilities, and for which there is uncertainty in its temporal and spatial availability, i.e. a nomadic nodes may shut-down its service, change its geographical position and then become available again. For example, the on-board communications infrastructure that will be deployed in future vehicles may serve for such purposes [9].

The MFemtocell is a new concept that has been proposed recently to be a potential candidate technology in next generation intelligent transportation systems. It combines the mobile relay concept (moving network) with Femto cell technology. An MFemtocell is a small cell that can move around and dynamically change its connection to an operator’s core network [10].

The deployment of small cell base stations (SCBSs) overlaid on existing macro cellular systems is seen as a key solution for offloading traffic, optimizing coverage, and boosting the capacity of future cellular wireless systems. The next generation of SCBSs is envisioned to be multimode (i.e., capable of transmitting simultaneously on both licensed and unlicensed bands). This constitutes a cost-effective integration of both WiFi and cellular radio access technologies that can efficiently cope with peak wireless data traffic and heterogeneous quality of service requirements. Cross-system learning allows the SCBSs to leverage the advantage of both the WiFi and cellular worlds. For example, the SCBSs can offload delay-tolerant data traffic to WiFi, while simultaneously learning the probability distribution function of their transmission strategy over the licensed cellular band [11].

III. ARCHITECTURE FOR MOVING CELL BEARER CONTROL

The envisioned moving cell network architecture consists of the Evolved Packet Core (EPC) and the Moving Cell Node (MCN). The motivation of this paper came after studying the concept of mobile relays, mobile networks and Mobile femto cells. The moving cell technology is a concept to further evolve fixed small cell technology for the next generation wireless system which is solved the rapid increase of traffic. It provides a continuous connection to the mobile network and moves around its connection network along to the user.

This section proposes the architecture of moving cell bearer control based LTE-A system which includes new reference points such as side-haul link (between two MCNs, e.g. sidelink direct communication, etc.), and access link (between MCN and UE, e.g. multi-radio access technologies such as WiFi, LTE-U, LTE, sidelink direct communication. etc.). Figure 1 shows the moving cell technology conceptual model for the LTE-A system. The Moving cell is introduced to provide a direct communication link (it means the side-haul link) between two MCNs, via access links (between UE and MCN) and increases capacity in a macro cell used local routing and local caching. The moving cell provides services inside vehicles and derives the need for closer integration across different RATs. The MCN is available to cooperate between WiFi and cellular RANs. The moving cell is connected wirelessly to an eNB via backhaul link, and to a MCN via side-haul link.

It is possible to create a new service model that is concentrated in the macro base station. It can provide a communication environment of moving between cells through the side-hauls and wireless backhaul, through cooperation of the movement between cells, and overcoming actively interference from the receiving end. It is a technique capable of increased capacity through the off-road. At the same time, the moving cell can use a dynamic clustering between the access devices and the mobile cell to reduce the energy consumed for communication with remote base stations of the connection device. It can minimize the battery consumption of the device. The moving cell core technology is comprised of efficient mobility control technology, interface technology, and interference technology.

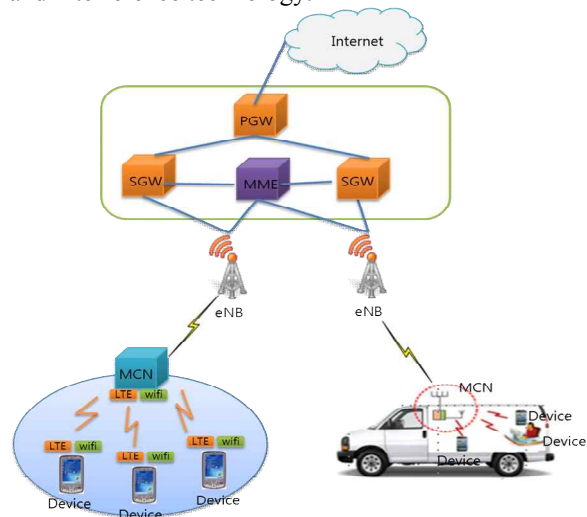


Figure 1. Use case Scenario of the proposed moving cell

We describe our proposed procedures for discovering the nearby MCN and establishing the MCN. We design a MCN establishing procedure based on the proposed network architecture. And the MCN configures itself through self-configuration process [12]. Figure 2 illustrates a call flow to provide the moving cell in detail. The procedure consists of two parts: MCN attach procedure like as UE, self-

configuration procedure as a newly added eNB(evolved Node B) with a dedicated backhaul interface.

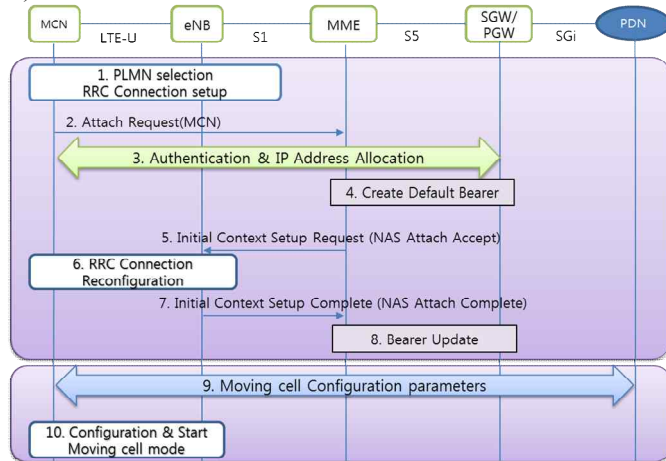


Figure 2. Establishing the Moving cell Node

IV. DESIGN OF MOVING CELL BEARER CONTROL AND MECHANISMS

In this section, we describe the call flow and bearer architecture for the moving cell.

A. Example bearer control call flow

Figure 3 shows the call flow for establishing bearer of a UE which has two radio accesses (e.g. LTE and WiFi). The MCN announces the moving cell Id for providing connectivity to UEs via D2D(Device-to-Device) communications. When a UE sends service request message via a WiFi, the MCN performs an establishment of the bearer for the WiFi radio bearer of the UE(in Fig.2. blue section). When a UE sends service request message via a LTE, the MCN acts the LTE relay node.

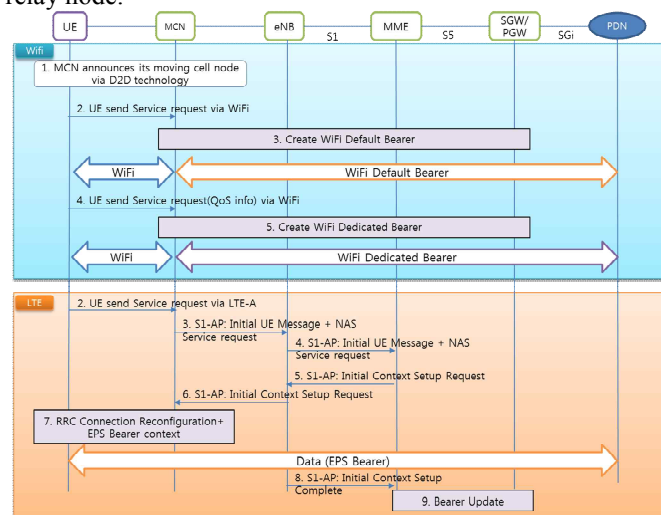


Figure 3. Setup of LTE-A and WiFi Bearers via Moving cell

B. Bearer model

Figure 4 shows a LTE-A bearer architecture at which a cellular communication is going on. For the communication path, UE has an EPS connection and EPS bearers which are associated to that connection. An EPS bearer consists of a radio bearer, S1 bearer, S5 bearer, and packet filters. The EPS bearer means a Quality of Service (QoS) based flow aggregates. A bearer is the level of granularity for bearer-level QoS control in the EPS. One bearer exists per combination of QoS class and IP address of the terminal. Each Packet Data Network (PDN) must have one default EPS bearer, but may have none to many dedicated EPS bearers.

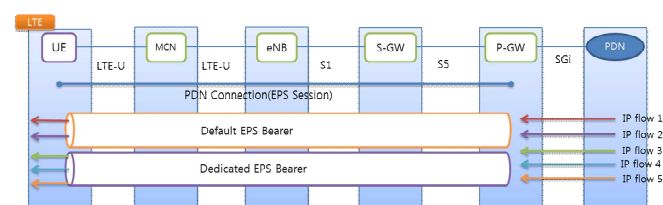


Figure 4. Bearer Architecture in LTE-A System

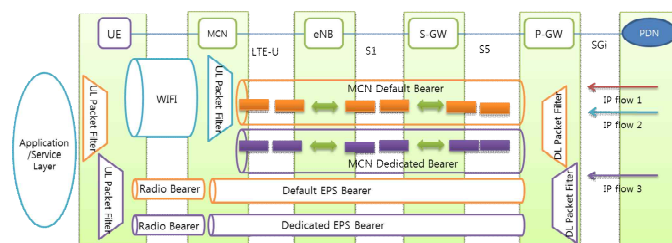


Figure 5. Bearer Architecture in the moving cell

Figure 5 shows the bearer architecture that includes the WiFi and LTE communication concept simultaneously and the different type of EPS bearers: default and dedicated for a moving cell bearer architecture.

C. Protocol stack

The protocol stack of the moving cell is shown in figure 6-7. We propose a moving cell node which is a very tight coupling between WiFi access points and LTE eNodeB. The main principle of the proposal is to keep all control functions in the LTE network and to use WiFi only to transmit data. When data are transmitted through WiFi, the MCN provides MCN default bearer and dedicated bearer such as EPS bearers.

Figure 6 shows the protocol stack of the moving cell control plane. Figure 7 shows the protocol stack of the moving cell user plane.

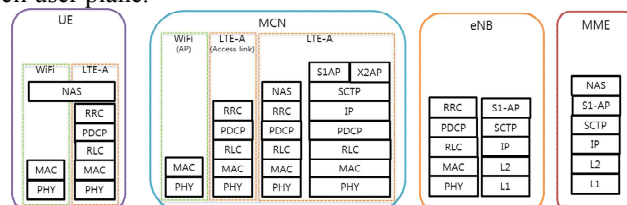


Figure 6. Control plane Protocol Stack for the Moving cell

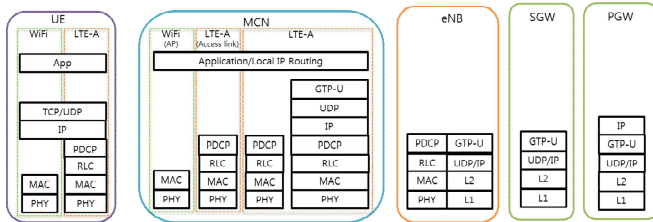


Figure 7. User plane Protocol Stack for the Moving cell

V. CONCLUSIONS

In this paper, we define a moving cell bearer control mechanism where WiFi access points are managed as parts of moving cell node and propose the concept of moving cell based LTE-A system. The moving cell has more benefits than other architecture (ex. Mobile relay, MFemtocell etc.). We propose the architecture moving cell in cellular system and manage the self-configuration process of the user centric moving cell effectively. This architecture can reduce the burden of network structure and procedures by solving an extension of LTE-A for moving cell structure. It is possible to accommodate a plurality of massive devices connected to the energy-saving. The user centric moving cell can be deployed freely and easily using proposed self-configuration mechanism in this paper. We presented the moving cell in LTE-A system for 5G. For future research, we will propose utilization methods for moving cell through the complement of insufficient technical points and analyse the development of the market and service.

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REFERENCES

- [1] Boyd Bangerter, Shilpa Talwar, Reza Arefi, and Ken Stewart, "Networks and Devices for the 5G Era," *IEEE Communication Magazine*, vol.52, pp. 90-96, Feb. 2014.
- [2] Olga Galinina, Alexander Pyattaev, Olga Galinina, Alexander Pyattaev, Sergey Andreev, Mischa Dohler, and Yevgeni Koucheryavy, "5G Multi-RAT LTE-WiFi Ultra-Dense Small Cells: Performance Dynamics, Architecture, and Trends," *IEEE Journal on Selected Areas in Communications*, pp. 1-17, march 2015.

- [3] Q. Li, G. Wu, and R. Hu, "Analytical study on network spectrum efficiency of ultra dense networks," *IEEE Symposium on Personal, Indoor, and Mobile Radio Communications*, pp. 2764-2768, 2013.
- [4] A. Gotsis and A. Alexiou, "On Coordinating Ultra-Dense Wireless Access Networks: Optimization Modeling, Algorithms and Insights," ArXiv preprint: <http://arxiv.org/abs/1312.1577>, 2013.
- [5] A. Gotsis, S. Stefanatos, and A. Alexiou, "Spatial Coordination Strategies in Future Ultra-Dense Wireless Networks," *International Symposium on Wireless Communications Systems*, pp. 801-807, 2014.
- [6] E. Dahlman, G. Mildh, S. Parkvall, J. Peisa, J. Sachs, and Y. Selen, "5G radio access," *Ericsson Review*, vol. 6, pp. 2-7, 2014.
- [7] S.-P. Yeh et al., "Capacity and Coverage Enhancement in Heterogeneous Networks," *IEEE Wireless Communication*, vol. 18, pp. 32-38, 2011.
- [8] Sergey Andreev, MIKHAIL GERASIMENKO, OLGA GALININA, YEVGENI KOUCHERYAVY, NAGEEN HIMAYAT, SHU-PING YEH, AND SHILPA TALWAR, "INTELLIGENT ACCESS NETWORK SELECTION IN CONVERGED MULTI-RADIO HETEROGENEOUS NETWORKS," *IEEE wireless communications*, vol. 22, pp. 86-96, December 2014.
- [9] METIS, Mobile and wireless communications Enablers for the Twentytwnty Information Society, EU 7th Framework Programme project, ICT-317669-METIS/D6.2
- [10] Cheng-Xiang Wang, Haider, F., Xiqi Gao, Xiao-Hu You, Yang Yang, Dongfeng Yuan, Aggoune, H., Haas, H., Fletcher, S., Hepsaydir, E., "Cellular architecture and key technologies for 5G wireless communication networks," *IEEE Communication Magazine*, vol.52, pp. 122-130, Feb. 2014.
- [11] Bennis, M., Simsek, M., Czylik, A., Saad, W., Valentin, S. and Debbah, M., "When cellular meets WiFi in wireless small cell networks," *IEEE Communication Magazine*, vol.51, pp.44-50, June 2013.
- [12] Honglin Hu, Jian Zhang, Xiaoying Zheng, Yang Yang, Ping Wu, "Self-configuration and self-optimization for LTE networks," *IEEE Communication Magazine*, vol.48, pp 94-100, Feb. 2010.



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