Dwell-time based Cell Association with Carrier Aggregation for Heterogeneous Cellular Networks

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Abstract: In heterogeneous networks (HetNet), it is an important issue to determine a suitable access network for call request to support seamless service and stable connectivity. For moving user equipment (UE), when and how to select a appropriate cell is more challenging. Since relatively long handover (HO) interruption time occurs due to the frequent HO, they experience significantly degraded data rate. Therefore, we propose dwell-time based multi-traffic cell selection method with carrier aggregation (CA) to reduce the effect of HO interruption time. Dwell time means the time UE stays in a cell. Using the dwell-time considered cell selection method, we expect increase average UE throughput by declining the interruption time. Simulation results show that our proposed scheme improve the UE experienced data rate.

1. INTRODUCTION

Over the past few years, introduction of new mobile devices arises an explosive increase in cellular traffic. To meet such a significant demand for wireless data capacity, heterogeneous network (HetNet) has played a central role [Yeh et al., 2011]. However, it is still inefficient to satisfy a peak data rate target of 1 Gbps established through the National Research Foundation of Korea(NRF) funded by (National IT Industry Promotion Agency)(NIPA-2013-(H0301-13- nology Research Center) support program supervised by the NIPA. This research was supported by the MSIP(Ministry of Science, ⋆

There have been many studies on CA with the purpose of supporting UE with high mobility becuase user mobility is not taken into account. To solve such a problem, a new concept of spliting the control and user (C/U) planes of the radio link is proposed [Ishii et al., 2012]. In LTE-Advanced, one promising approach is to extend the transmission bandwidth by carrier aggregation (CA) in order to increase data rate [Parkvall et al., 2011].

However, it is still difficult to make full use of those schemes to support UE with high mobility because user mobility is not taken into account. To solve such a problem, a new concept of splitting the control and user (C/U) planes of the radio link is proposed [Ishii et al., 2012]. According to [Pedersen et al., 2013], macro BS(mBS) is selected as a C-plane cell regardless of traffic condition for a high speed UE and U-plane cell is choosed based on expected data rate. However, although UE may have a good connectivity through C-plane, they might not be provided high data rate by U-plane when frequent U-plane cell changing happens. In this paper, a dwell time based cell seletion method is proposed to prevent unnecessary HO and thus improve the average UE throughput.

2. SYSTEM MODEL

In this paper, we focus on the downlink data transmission of HetNet which is macro and small cells are coexisted forming hotspots. Let us assume that macro base station(mBS) and hotspot are randomly located according to a homogeneous Poisson Point Process(PPP) with density $\lambda_M$ and $\lambda_H$, respectively. Also, small cell base station(sBS) is randomly distributed according to a homogeneous PPP with density $\lambda_S$, over a circle with radius $R$ centered at hotspots.

The transmission total power of mBS and sBS are $P_M = 46dBm$ and $P_S = 30dBm$ with the thermal noise $N_0 = -104dBm$. There is a set of $\mathcal{M}$ available bands denoted as $\mathcal{M} = \{800MHz, 2.6GHz, 60GHz\}$. For mBS, it only uses $800MHz$ band and for sBS, it uses both $2.6GHz$ and $60GHz$ bands. The bandwidth, the path loss coefficient and the number of cell on band $m$ are denoted by $B_m(\{B_{800MHz} = 10MHz, B_{2.6GHz} = 10MHz\}$ and $B_{60GHz} = 2GHz$ ), $\alpha_m(\alpha_{800MHz} = 3, \alpha_{2.6GHz} = 4$ and $\alpha_{60GHz} = 5$) and $I_m$, respectively.

Also, we presume that density of UE is $\lambda_U$ and the ratio of moving UE to stationary UE is $\rho_U$ to $\rho_S$. Stationary UE is located according to a homogeneous PPP with density $\lambda_U$ and the rest of UE travels over a predefined straight road with a mobility $v$. Mobility are i.i.d with distribution function $f_u(v)$.
3. PROPOSED CELL ASSOCIATION WITH CA

For a moving UE with a high speed, to maintain a stable connectivity is important matter for UE to be served. Therefore, we split C/U-plane to last the connection without breaking up as in [Ishii et al., 2012]. In the conventional method adopting the 3GPP carrier aggregation terminology, it translates to assuming that UE devices are assumed to have their PCell configureed on the macro layer [Pedersen et al., 2013]. In this paper, the proposed scheme also choose a C-plane cell based on connection power and cell coverage. Thus, C-plane cell are selected as follow.

\[ C(i_m)_{conv} = C(i_m)_{pro} = \arg \max_{i_m \in I_m, n_{i_m}=800MHz} RSRP_{i_m} \] (1)

where RSRP\(_{i_m}\) is reference signal received power (RSRP) of \(i_m\)th cell on band \(m\).

Before describe U-plane cell selection, we discuss the procedure and set several assumption on the conventional and proposed scheme. U-plane cell selection goes through the procedure as follow. UE calculates achievable data rate averaged on whole bandwidth \(B_m\) and reports the results to a central eNB directly. In the case of the conventional method, the central eNB determines association results based on information of current number of UE associated to each nodes, \(n_{i_m}\). However, in the proposed scheme, we suppose that the central eNB is informed additionally about dwell time of UE according to a specific mobility range. In this paper, we set 5 different mobility ranges \(v_q=\{1, 2, 3, 4, 5\}\) where \(v_1 = 10 \text{ km/h}, v_2 = 20 \text{ km/h}, v_3 = 40 \text{ km/h}, v_4 = 80 \text{ km/h}\) and \(v_5 = 150 \text{ km/h}\). This is because dwell time is rapidly declined below velocity 100 km/h. Therefore we subdivided the velocity more finely within the range. Then, the central eNB can classify dwell time \(t_{i_m, v_q}\) according to the mobility set \(v_q\) and cell coverage on band \(m\).

For a data transmission, in the conventional method, UE calculates achievable data rate averaged on whole bandwidth \(B_m\) to select U-plane cell as follow.

\[ R_{i_m} = B_m \times \log(1 + \gamma_{i_m}) \] (2)

where \(\gamma_{i_m}\) is Signal to Interference plus Noise Ratio (SINR) of \(i_m\)th cell on \(m\).

And UE reports the information to a central eNB directly and the eNB determines association results based on the information as well as the current number of UE associated to each nodes. Thus, U-plane cells selection criteria can be described as follow.

\[ U(i_m)_{conv} = \arg \max_{i_m \in I_m, n_{i_m} \in M} R_{i_m} / n_{i_m} \] (3)

where \(n_{i_m}\) is the number of UEs associated to \(i_m\)th cell on band \(m\).

Even though the scheme takes the channel condition and load balance into account to fully exploit small cells, it overlooks the fact that the criteria based on instantaneous information can occur a rapid transition. With regard to appropriate U-plan cells, we should avoid a sudden change by considering quantized dwell time information.

As mentioned above, in the proposed scheme, eNB is informed not only current nodes’ traffic load but dwell

Fig. 1. Proposed SCell selection method

time of UE. Based on the information, we define effective load coefficient \(E_{i_m, v_q}\).

\[ E_{i_m, v_q} = \frac{(t_{i_m, v_q} - t_{HO})}{n_{i_m}} \] (4)

where \(t_{i_m, v_q}\) is dwell time of UE with the mobility \(v_q\) in \(i_m\)th cell on band \(m\). \(t_{HO}\) is set up time that UE measures RSRP, reports the information to a central eNB, and receives the association results from the central eNB.

Among candidates, we choose U-plane cell which has the largest obtainable data rate multiplied by effective load \(E_{i_m, v_q}\) as follow.

\[ U(i_m)_{pro} = \arg \max_{i_m \in I_m, n_{i_m} \in M} R_{i_m} \times E_{i_m, v_q} \] (5)

4. PERFORMANCE EVALUATION

In this section, system-level simulation results are presented to verify our proposed scheme improve UE average throughput.

We compare the UE average throughput between the proposed scheme and the conventional scheme. In Fig.1, the average throughput of total UEs according to increase of moving UE ratio \(\nu_{i,m}\) is plotted. As the moving UE ratio increases, both schemes show declined average UE data rate. However, the proposed schemes reduce degree of decrease compare to the conventional method. It proves that dwell-time based cell selection method is useful for moving UE.

REFERENCES


