HaPT : Handover Prediction Using Temporal Data for Improved QoS in RAN

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ABSTRACT

In this paper, we propose HaPT, an active intra-LTE handover framework which integrates the user data-consumption trends to address the issue of unbalanced load on the mobile network. Eventually, it ameliorates the QoS for the end-user. HaPT uses ARIMA (Auto Regressive Integrated Moving Average) model for user data-consumption forecasting in order to make handover decision for the target UE. It also leverages multiple current load metrics to identify the target eNB. To avoid loss of service quality leading to call drops, call disturbances etc., proposed system also utilizes RSSI as one of its key metrics to make decision on the destination cell or eNB. We simulate the user mobility using LTESim during handovers using two mobility models Random walk and Random direction.

1 INTRODUCTION

The global IP traffic is exploding with each year passing by and this rapid outgrowth is a result of increasing number of applications supported by the internet, for eg. healthcare, VR, AR etc. Some of these applications require a high QoS and high throughput for uninterrupted delivery of content.

The heterogeneous distribution of eNBs and the end devices some times leads to lower QoS due to the high demands of IP traffic in areas which have higher concentration of end-users as compared to the area with lower numbers. These numbers are subject to change and are dynamic in nature. For example a large scale event in an area with great number of mobile users could lead to congestion and loss of service quality. A large change in the number of connected end users could lead to a situation of interrupted service and lowered QoS. Our HaPT design is motivated by the following questions: *How to make decisions for UE to be handed over? How the user behaviour and network load conditions could both benefit the handover procedure?* Our key contributions are :

- HaPT as depicted in Figure 1 provides a trade-off between sufficient signal strength and current load conditions at eNB within several hops to balance load between them.
- HaPT tries to enforce maximum throughput policy to maintain QoS, uses UE data consumption predictions, and RSSI strengths to make control decisions on which UE is to be handed over to which target eNB.

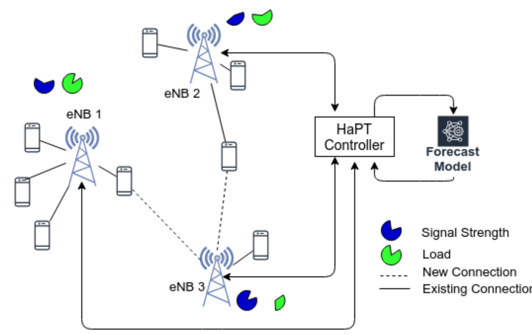


Figure 1: Cellular network with HaPT controller framework.

2 HAPT FRAMEWORK

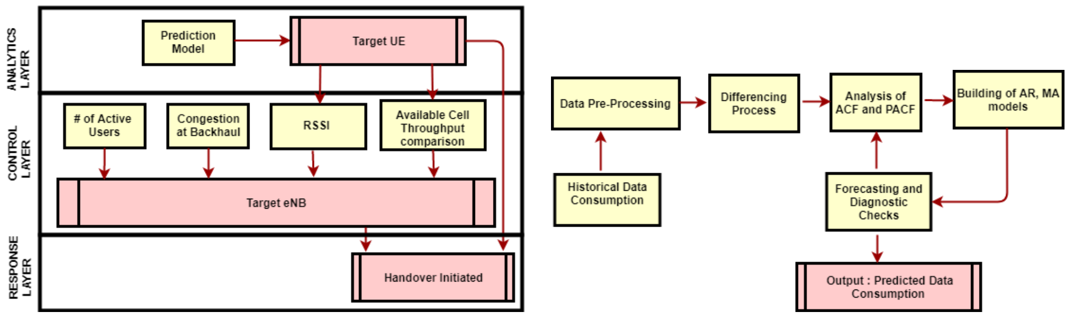
As shown in Figure 2, HaPT framework consists of three layers (i) Analytics Layer, (ii) Control Layer, (iii) Response Layer. **Analytics Layer.** This layer utilizes the data-consumption historical trend along with their IMEI numbers to forecast future data consumption. As shown in Figure 2, we use ARIMA model to predict the future values. ARIMA is a combination of AR (Auto Regressive) and MA (Moving Average) models. It uses past values, own lags and the lags of forecast errors of the temporal data-consumption data, and thus allows us to arrive at prediction P_t.

$$\mathrm{P_t} = \alpha+\beta_1 P_{t-1}+\beta_2 P_{t-2}+\beta_n P_{t-n}+\varepsilon_1+\varphi_1\varepsilon_{t-1}+\varphi_2\varepsilon_{t-2}\ldots+\varphi_m\varepsilon_{t-m} \quad (1)$$

$$\varepsilon_{t-n} = P_{t-n} - (\beta_1 P_{t-n-1} + \beta_2 P_{t-n-2} + \ldots \beta_0 P_0) \quad (2)$$

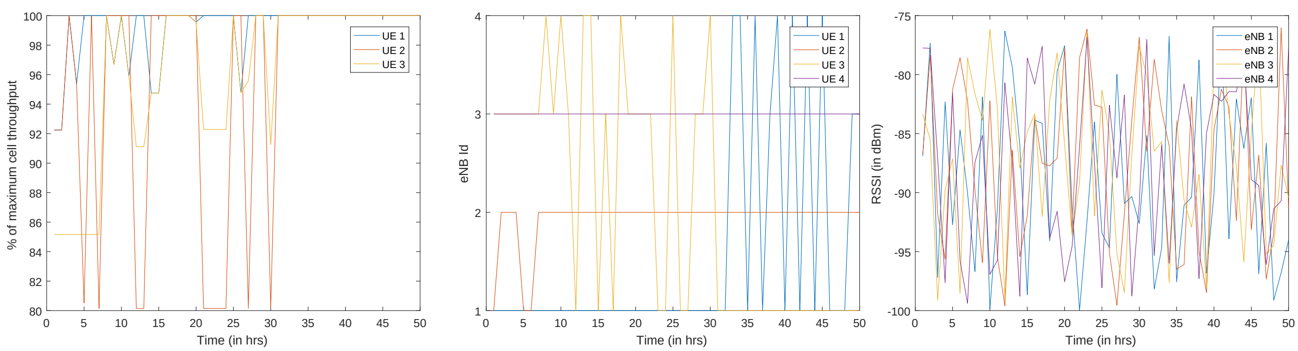
where α is the intercept term, β is the coefficient of lag and ε_n is the n^{th} error term. These values along with other essential parameters of ARIMA are supported by the analysis of autocorrelation and partial auto correlation functions. The model is expected to produce a mean error of less than 6%.

Control Layer. This layer consists of the control logic for the HaPT framework and calculates the target eNB to which the target UE in the analytics layer will be handed over to. The decision on the target eNB relies on various factors listed below (i) Number of activeusers at each eNB within two hops, (ii) Congestion at the back-haul of each base station provides a reliable metric for current load, based on latency due to



(a) HaPT Framework **(b) ARIMA Prediction Model**

Figure 2: Design of (a) HaPT Framework, (b) Prediction Model.



(a) **(b)** **(c)**

Figure 3: HaPT's (a) throughput evaluation of the UEs as a percentage of maximum micro cell throughput, (b) handover history by utilizing (c) RSSI (UE-3) values.

increased number of UE connected to the eNB, (iii) RSSI (Recieved Signal Strength Identifier) values are used to verify the reliability of service and is restricted to remain between upper and lower thresholds for the handover to be successful, (iv) Available cell throughput gives an estimate about current cell occupancy against it's maximum cell occupancy limit. All the above information is exchanged between the eNB using the X2 (X2 is the interface between two eNB) interface and is stored locally at each eNB in a `sql` database. The control logic for HaPT resembles the central manager algorithm [2].

Response Layer. The response layer acts in accordance to the decision of the analytics layer and control layer. With the help of a scheduler and X2-interface it initiates the handover procedure by setting up X2-TransportBearer between source and target eNB followed by a detach from source eNB.

3 HAPT EVALUATION

Currently, HaPT has been implemented with both `Python` and C++. We test HaPT using `LTESim` [1] simulation framework. The test environment consists of 4 eNB with UID 1-4 and 15 UE with UID 1-15. The random congestion scenarios have been created by adding a virtual backhaul for the eNB and injecting traffic using `iperf` as well as changing the backhaul capacity. The ARIMA model have been trained using Telecom Italia Open big data challenge dataset. Figure 3(a) and (b) shows the HaPT handover history and throughput for 4 UEs over 50 hours and Figure 3(c) shows the RSSI values of UE with UID 3 for all the base stations. Each of the UE is subjected to either a random direction or random walk mobility model to mimic user mobility. As evident in Figure 3, with each handover HaPT tries to maximise the UE throughput for target UE in accordance to the enforcement of maximum throughput policy to improve QoS.

REFERENCES

[1] LTESim 2019. Github repository. https://github.com/lte-sim/lte-sim-dev. (2019). Accessed: 6-7-2019.

[2] Eep Sharma, Sarabjit Singh, and Meenakshi Sharma. 2008. M.: Performance Analysis of Load Balancing Algorithms. In *In: 38th World Academy of Science, Engineering and Technology*. 269–273.