I. System Model

Traffic Steering Strategies (TSS) exhibits different performance improvement. It is been observed with our experiments that WoD is better than NLAS. Here, we have captured the improvement because of using WoD compared to NLAS.

A. Increase in throughput because of WoD-Saturated Throughput case

According to [**?**] when n nodes are in the network and a node transmits with a probability τ. Then, probability that atleast a transmission happen (P_{tr}), and probability of a successful transmission (P_s) is given by

$$P_{tr} = 1 - (1-\tau)^n \tag{1}$$

$$P_s = \frac{n\tau(1-\tau)^{n-1}}{P_{tr}} \tag{2}$$

Here, P_s is obtained using Discrete Time Markov chain analysis. Consider that among n users in the network, if m users were served by LWIP node, $m \in [0, n-1]$ and rest $(n-m)$ users contend for the channel in Wi-Fi link. In case of Wi-Fi only in Downlink the number of node contending for the channel gets reduced, which leads to reduction in collision. This is only feasible if there is a secondary carrier like LTE to take the uplink data. The probability of success (P_s^{WoD}) when m nodes are non contending is given by.

$$P_{tr}^{WoD} = 1 - (1-\tau)^{n-m} \tag{3}$$

$$P_s^{WoD} = \frac{(n-m)\tau(1-\tau)^{n-m-1}}{P_{tr}^{WoD}} \tag{4}$$

Lemma 1 : Effective improvement in probability of success will be

$$P_s^{inc} = P_s^{WoD} - P_s \tag{5}$$

$$P_s^{inc} = \frac{(n-m)\tau(1-\tau)^{n-m-1}\big(P_{tr}^{WoD} m(1-\tau)^m - P_{tr}\big)}{P_{tr}P_{tr}^{WoD}} \tag{6}$$

Corollary 1: In WoD, when $m > 1$ and $\tau \geq \tau_{n-m}^{sat}$, makes $P_{tr}^{WoD} m(1-\tau)^m - P_{tr}$ to be greater than zero, will lead P_s^{inc} to be strictly a positive quantity. τ_{n-m}^{sat} corresponds to τ value for which $(n-m)$ devices achieve maximum throughput.

Saturated system throughput when n nodes content for the channel is given by

$$S_{wi-fi} = \frac{P_s P_{tr} E[P]}{(1-P_{tr})\sigma + P_{tr}P_sT_s + P_{tr}(1-P_s)T_c} \tag{7}$$

Where σ corresponds to empty slot time, T_s corresponds to average time (slots) when channel is sensed busy and T_c is the average time (slots) channel is busy due to collision. $E[P]$ is the average payload size in slots. System throughput in WoD (S_{WoD})is given by

$$\frac{P_s^{WoD} P_{tr}^{WoD} E[P]}{(1-P_{tr}^{WoD})\sigma + P_{tr}^{WoD}P_s^{WoD}T_s + P_{tr}^{WoD}(1-P_s)T_c} \tag{8}$$

The load in UL and DL are non symmetric, Data demand in DL is high which naturally makes WoD as a preferable choice compared to NLAS. If UL and DL are symmetric then WoD will be preferred only if the overall system delay of WoD is lesser than NLAS.

II. Improvement in throughput

III. Reduction in collision

$$P_c = 1 - (1-\tau)^{n-1} \tag{9}$$

$$P_c^{WoD} = 1 - (1-\tau)^{n-m-1} \tag{10}$$

$$\gamma_c = 1 - (1-\tau)^{n-1} - \big(1 - (1-\tau)^{n-m-1}\big) \tag{11}$$

$$\gamma_c = (1-\tau)^{n-1}\Big(\frac{1}{(1-\tau)^m} - 1\Big) \tag{12}$$

as the number of non contending nodes m is a positive quantity then, γ_c is strictly positive which concludes that there is strict reduction in the observed number of collision.

IV. Amount of Wastage time reduced