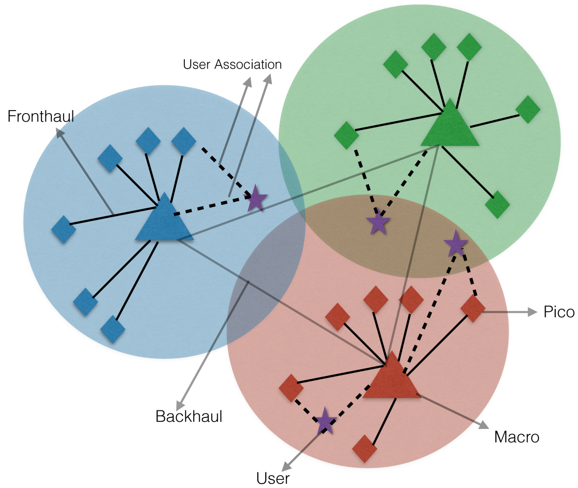

Fig. 1. Dual Connectivity Schematic

$$\begin{aligned}\max_{z_{u,m},x_{u,b}\in\{0,1\},\gamma_{u,b},\theta_{u,m}\in[0,1]\ \forall\, u\in\mathcal{U},b\in\mathcal{B}_m,m\in\mathcal{M}} &\left\{\sum_{u\in\mathcal{U}}\sum_{m\in\mathcal{M}}\sum_{b\in\mathcal{B}_m} x_{u,b}\ln\left(R_{u,m}\theta_{u,m}+R_{u,b}\gamma_{u,b}\right)\right\}\\ \text{s.t.} \sum_{m\in\mathcal{M}} z_{u,m}=1;\ \sum_{b\in\mathcal{B}_m} x_{u,b}&=z_{u,m},\ \forall\, u\in\mathcal{U},m\in\mathcal{M};\\ \sum_{u\in\mathcal{U}}\theta_{u,m}\le 1\ \&\ \sum_{u\in\mathcal{U}}\gamma_{u,b}&\le 1\ \forall\, b\in\mathcal{B}_m,m\in\mathcal{M}.\end{aligned} \tag{2}$$

We next consider the PF system utility and adopting the convention that $0\ln(0)=0$, we pose a mixed optimization problem given in (2). The first set of constraints in (2) ensures that each user is associated with exactly one macro. As before, exploiting DC each user that is associated with the macro TP m is also associated with any one pico TP in $\mathcal{B}_m$.

Note that our formulations assume an infinitely backlogged traffic model with no limits on buffer sizes at any TP. Coordination among TPs happens at frame boundaries where the user association can be altered. After a transient phase (whose length can be ignored), for each user distinct data streams are available for downlink transmission at its assigned macro as well as its assigned pico node. This setting bestows tractability while being relevant. Extending our results to a more realistic formulation with finite buffers entailing careful data forwarding (from each macro to each pico assigned to it) is an interesting topic for future work.