CELLULAR NETWORK OFFLOADING THROUGH DRONE COOPERATION

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ABSTRACT

Base station (BS) capacity for cellular networks is fixed and therefore cannot be easily adapted to support temporary high demands due to unusual traffic (demonstration, sales, competitions, etc.). Unmanned Ariel Vehicle (UAV)/drone can be used as an additional temporary bandwidth (BW) provider capable of covering multiple cells. Two placement approaches are investigated to optimize UAV deployment for this purpose. The first adopts a rule based approach without cooperation: we place UAVs in the cells where the exceeding demand is the highest, allowing each UAV to only serve a single cell at a time. In the second algorithm, relying on the Knapsack problem, we design a solution where UAVs cooperate by sharing a portion of their available BW with neighbouring cells in order to cover all the demand with the lowest possible amount of drones. Their performance is compared using two months of real dataset from the Milan Cellular Network provided by Telecom Italia.

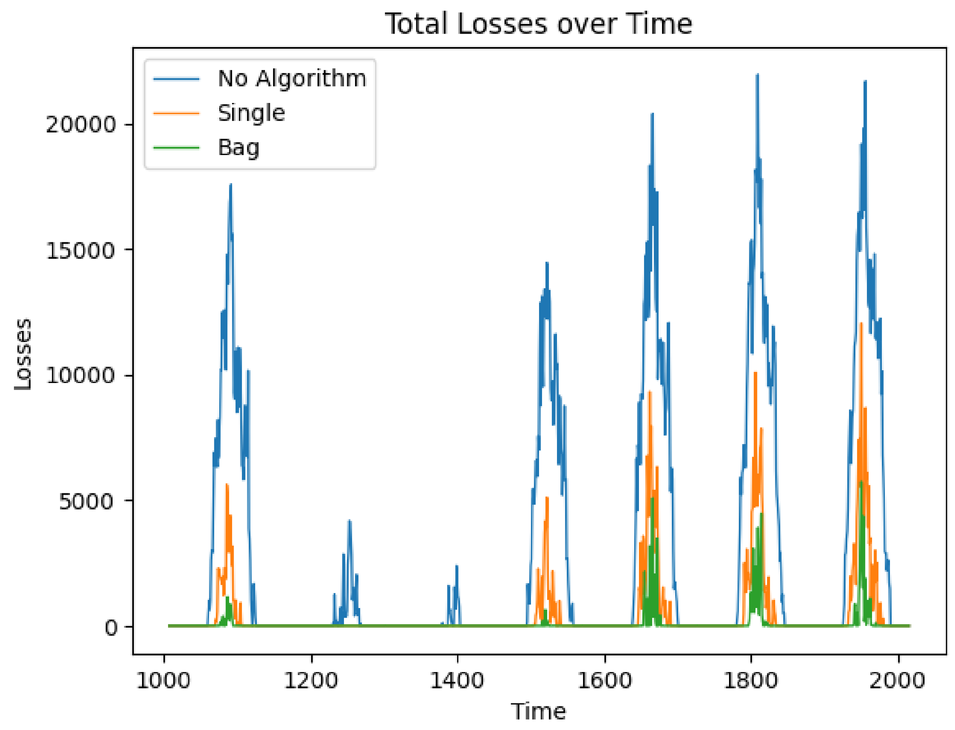
METHOD

TWO MODELS : SINGLE AND KNAPSACK

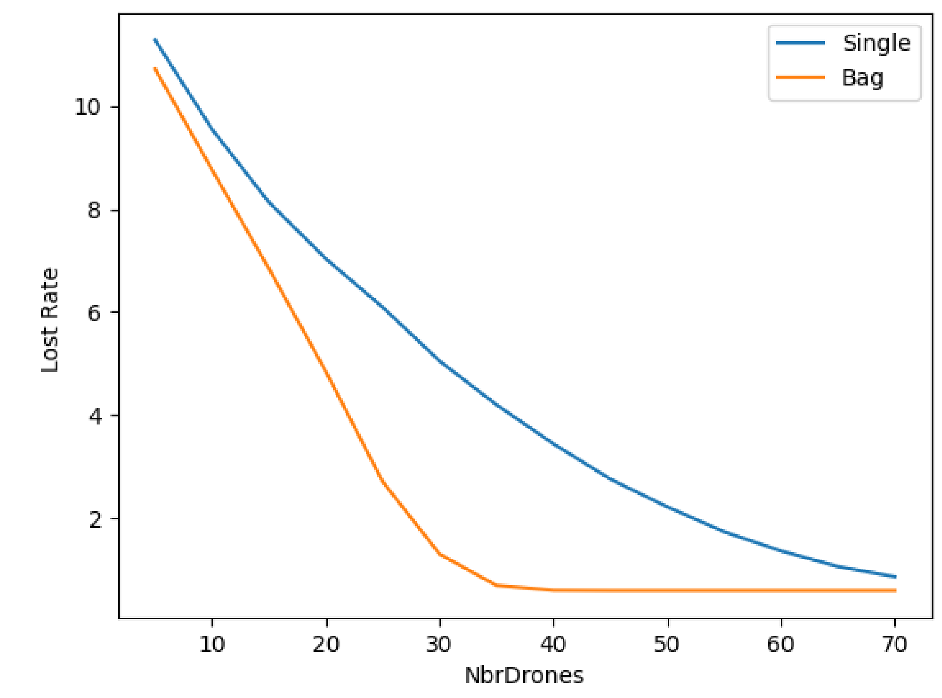
- The rule-based algorithm is placed to optimize the cell resources when there is a need for extra resources due to an over demand. The inputs are the time of the day, cells numbers, drones numbers and drones in the charging station, each cell BW, the extra BW needed and idle/serving drones in each cell
- The knapsack algorithm is an updated version of the rule-based (also named single) algorithm which aims to optimize the use of each drone capacity. While for the rule-based algorithm we considered that a drone serves one cell at a time, now the knapsack algorithm allows a drone to serve multiple cells at the same time. It uses a score function to evaluate how a drone needs to move to a cell to offload it and its cluster. We try to put drones in the most central cells in terms of demand

MAIN RESULTS

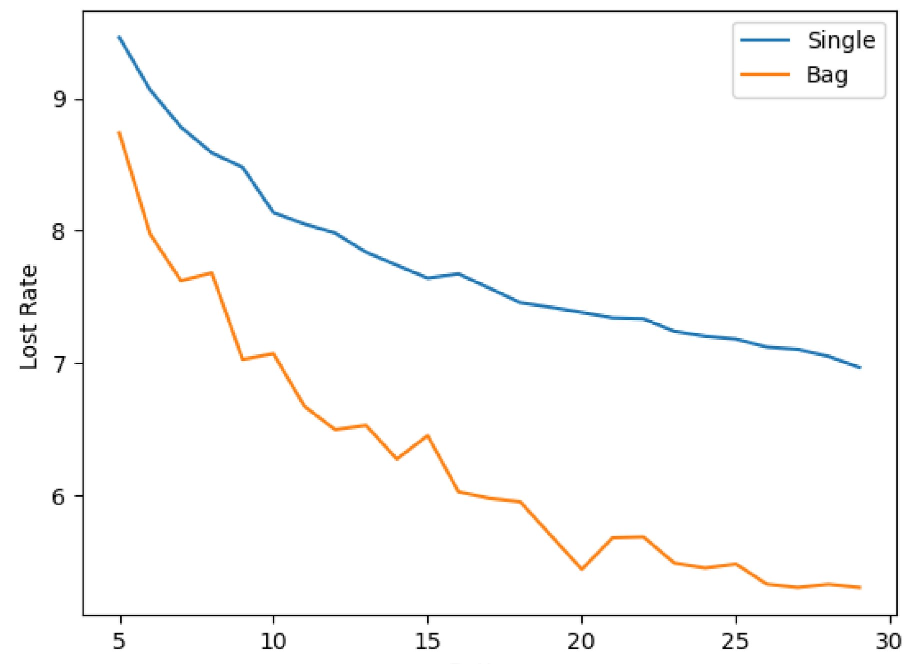
LOST RATE, CHARGING TIME, BATTERY AND ENERGY CONSUMPTION



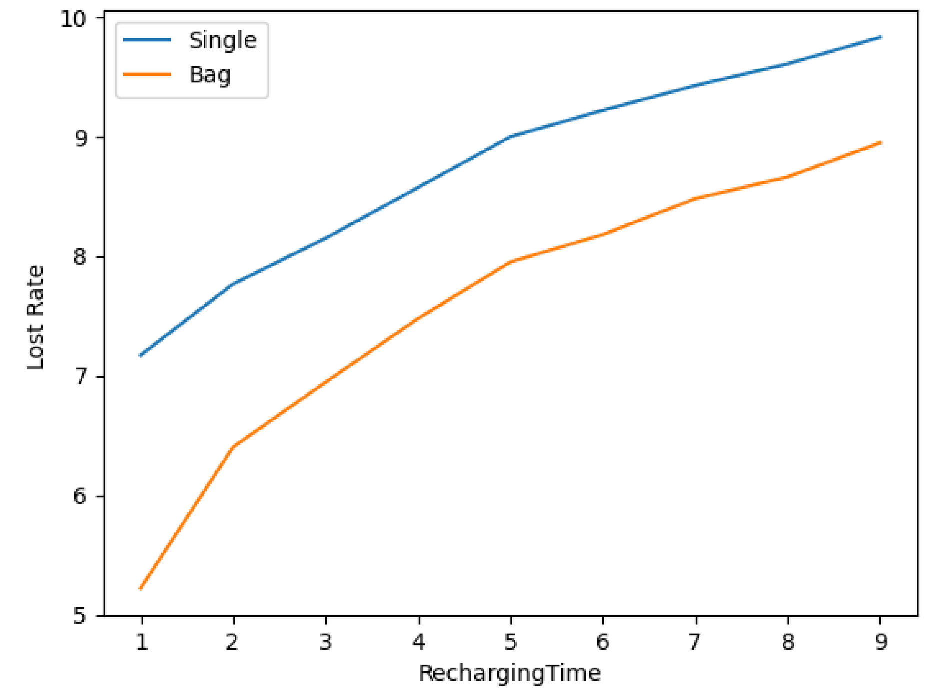
Total Losses 20 drones



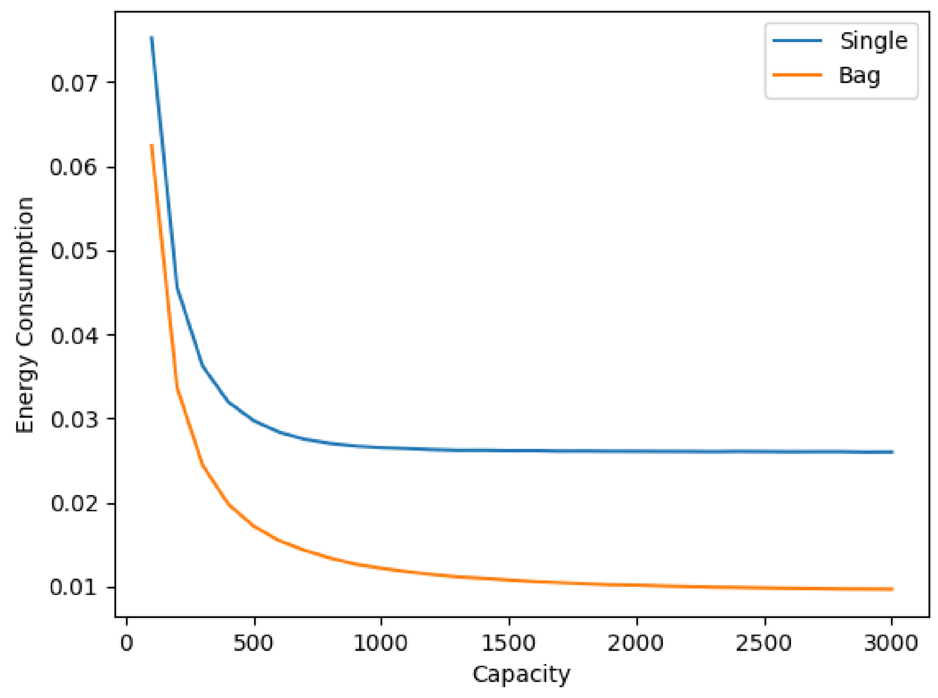
Lost Rate with fixed capacity for each drone



Impact of the Battery



Impact of the charging Time



Energy consumption per cell per unit of time with infinite number of drones

CONCLUSION

Drones have been proved to be cheap and flexible solution to address the problem of managing peak demand in cellular networks. In this paper, we propose a rule-based algorithm to address single drone coverage of multiple cells. Nevertheless, drone placement remains a challenging problem since there is interdependence between cells demand and drones that can serve several cells simultaneously. For this reason, in this paper we investigated the impact of cooperation between drones to serve multiple cells in a cellular network. We designed this algorithm based on a score function whose parameters can be specified depending on the importance to be given to the neighboring cells of the central one where a drone is placed. The two algorithms are compared using a real dataset in the region of Milan, Italy, giving demand records at each time instant and per cell over a total of 400 cells. While the "single" algorithm is simple to implement and gives good results, cooperation allows to reach much better results and it reduces the amount of drones to meet all the demands. Collaboration between drones has been shown to be effective.

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RELATED WORK

1. D. Qiu, A. Samba, H. Afifi, and Y. Gourhant, “Transforming urban fabric into mobile call traffic signatures,” in ICC 2022 - IEEE International Conference on Communications, 2022, pp. 377–382.
2. C. Boucetta, B. Nour, S. E. Hammami, H. Moungla, and H. Afifi, “Adaptive Range-based Anomaly Detection in Drone-assisted Cellular Networks,” in 2019 15th International Wireless ommunications Mobile Computing Conference (IWCMC), 2019, pp. 1239–1244.
3. M. E. Morocho-Cayamcela, W. Lim, and M. Maier, “An optimal location strategy for multiple drone base stations in massive mimo,” ICT Express, vol. 8, no. 2, pp. 230–234, 2022. [Online].

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