# Article Review

## L2D2: Low Latency Distributed Downlink for Low Earth Orbit Satellites

## Summary

The paper introduces L2D2, a novel framework for downlink applications of low earth orbit satellites. L2D2 utilizes multiple low-cost commodity hardware units to enhance the reception range, thereby providing a cost-effective alternative to the conventional approach of relying on a limited number of expensive ground stations. The framework features a centralized backend scheduler that employs a pre-trained machine learning model to predict link data rates and utilizes a greedy approximate algorithm to search for an optimal pairing of satellite and ground station that maximizes user-defined value functions. The optimal pairing is communicated to ground stations via control messages sent over the internet, and a newly proposed delayed acknowledge mechanism reduces the need for satellite backup. Simulation experiments have demonstrated that L2D2 outperforms the baseline in terms of higher throughput, lower latency, and reduced satellite backlog data.

## Strength and Weakness

**Strength:**

1. The utilization of low-cost ground stations facilitates the scalability of the system. In addition, geographically distributed ground stations permit more frequent communication between low-earth orbit satellites and ground stations, and offer finer access control for different ground stations, further enhancing the system's flexibility.

2. The newly proposed framework significantly reduces overall latency and enhances the resilience of the ground stations against external factors, such as weather interference. This development enhances the feasibility of various low-earth orbit satellite applications in the future, making them more reliable and practical.

3. By integrating actual low-earth orbit satellite data and open-source SatNOGS data, the authors simulate a large number of low-earth orbit satellite datasets, which is advantageous for future research.

**Weakness:**

1. The framework's centralized backend scheduler for optimization adds to communication overhead and incurs significant computation costs when dealing with many satellites and ground stations.

2. The one-to-one pairing of satellites and ground stations mechanism in the framework poses limitations, as different satellites may compete for access to the same ground station.

3. The framework's SNR prediction relies on data-driven approaches, which suffer from typical problems, including the need for a period of observation time to collect data for model training, additional costs associated with training models, and the requirement for online model updates and scaling-up.

## Questions

1. The author kept the XGBoost parameters fixed during transfer learning. However, if the nature of the newly added ground station differs significantly from the ground stations in the training dataset, will it result in poor performance of the finetuned model? (The error presented in the paper is plausible, but the testing dataset used in the study is relatively small) As for the design philosophy, what motivated the decision to keep the XGBoost component rather than remove it?

## Conclusion

The paper presents a framework for low earth orbit satellites application. It primarily focuses on addressing the issues that arise during the scaling up of the entire system. Despite the simplicity of the problem, the proposed solution is not trivial. The paper showcases how to accurately describe the problem while emphasizing the non-trivial aspects of the proposed ideas and solutions.