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TOWARDS AUTONOMOUS SATELLITE COMMUNICATIONS: AN AI-BASED FRAMEWORK TO ADDRESS SYSTEM-LEVEL CHALLENGES

Abstract

The next generation of satellite constellations is designed to better address the future needs of our connected society: highly-variable data demand, mobile connectivity, and reaching more under-served regions. Artificial Intelligence (AI) and learning-based methods are expected to become key players in the industry, given the poor scalability and slow reaction time of current resource allocation mechanisms. Previous work proves these methods are capable of making power allocation or frequency assignment decisions for different satellite systems and are capable of matching state-of-the-art performance. However, while AI frameworks have been validated for these isolated communication tasks or subproblems, there is still not a clear path to achieve fully-autonomous satellite systems. Part of this issue results from the focus on subproblems when designing models, instead of the necessary system-level perspective. In this paper we try to bridge this gap by characterizing the system-level needs that must be met to increase communications satellite autonomy, and introduce three AI-based components that jointly address them: Demand Estimator (DE), Offline Planner (OP), and Real Time Engine (RTE). We first do a broad literature review on the different subproblems and identify the missing links to the system-level goals. In response to these gaps, we outline the three necessary components and highlight their interactions. Given user base with a diverse set of connectivity requirements, our framework poses the DE as a predictive tool to forecast users' behavior in the short- and long-term. The role of the OP is to identify the key resource allocation decisions that have a lasting impact on the system performance and to optimize the resource allocation for the whole operation cycle of the constellation. We identify the estimation of uncertainty as one of the factors that is most detrimental to the performance of upcoming AI-based systems. In that sense, we propose the RTE as a way of correcting the necessary resource allocation decisions when unexpected events occur. We conclude the paper by discussing how current literature models can be incorporated into our framework and highlighting possible directions of future work.