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EDGE COMPUTING IN SPACE: A FRAMEWORK FOR ASSESSING ON-ORBIT PROCESSING AND MACHINE LEARNING APPLICATIONS.

Abstract

The extensive range of sensors, devices and instrumentation on-board the spacecrafts drifts into a huge amount of data to be processed. Usually, a bent-pipe architecture is used to send raw data down to Earth as a reply to ground station requests. However, it has been shown that the bent-pipe approach does not scale as data volume grows with constellation size and sensor quality, due to physical constraints such as ground station location and link availability. To deal with this, the present paper explores the edge computing approach which aims to reduce the latency and bandwidth within a link, by giving the capability to a system for processing the data as close as possible to where it has been generated, by placing processing hardware near to the source. We address two case studies based on a set of criteria to assess the suitability of edge computing, based on the application and underlying technology. For evaluating this approach, the payload of the next CubeSat generation developed at the University of Luxembourg will be used as the device-under-test for real-time data processing. A series of cameras will be located pointing to the electronic circuits of the payload to act as an edge-sensing component, while, a Field-Programmable Gate Array (FPGA) will act as an edge-computing system to process the raw data in orbit. Moreover, edge computing along with machine learning algorithms and models could lead to faster and more robust decision-making. Thus, the data collected by the cameras will be injected into machine learning algorithms to develop thermal profiles of the payload. Following these lines, for the second case study, the attitude and control system will act as an edge-sensing component, where, the data will be also injected into machine learning algorithms to generate attitude control profiles and predict abnormal behaviours in the satellite. We conclude that edge computing in space along with machine learning algorithms and models could accelerate local decision-making and data processing by increasing autonomy in space systems. Nevertheless, edge computing applications have to be carefully selected at an early stage, as its benefits only materialize under specific conditions.