Paper ID: 58291
student

27th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Constellations and Distributed Systems (7)

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# SCHEDULING DISTRIBUTED COMPUTATION IN SATELLITE CONSTELLATIONS

**Abstract**

With improvements in onboard processors and communications, the distributed processing of mission related data within a constellation is becoming a realistic proposition. However, there are several scheduling challenges in this environment that are not encountered within traditional multiprocessor scheduling problems. For example, computing on a constellation featuring inter-satellite links will have predictable, time-varying delays for messages passed on these links, due to variations in the inter-satellite distance as determined by the orbital elements of the constellations. Traditional scheduling schemes approximate completion time as a worst-case constant delay, so modeling the delay of the inter-satellite links would be limited to the greatest delay found within the scheduling window. Approximating the delay with a linear function will yield at least as good results, while not increasing the time complexity of the schedule. This approximation can also be beneficial in cases where onboard processors use dynamic voltage and frequency scaling to accommodate energy demands. Considering that both of these behaviors are not unreasonable within a constellation, a closer approximation can improve the performance of scheduling for a wide range of potential on-constellation processing applications.

In this paper, we consider one such case, an earth observation satellite constellation with inter-satellite links that is processing images within the constellation. The constellation orbital elements are derived from the Starlink constellation, an example case of inter-satellite link usage in a constellation. The image processing payload is based on an object detector for nadir imagery, the winner of the IARPA 2017 Function Map of the World challenge, which can be divided into separate sub-tasks for assignment onto different members of the constellation with input and output messaging requirements. This example demonstrates the time-varying communication delay present in the inter-satellite links.

We formulate the scheduling problem as mixed-integer linear programs minimizing the image processing latency. First, we introduce a scheduling scheme using the worst-case constant delay for the completion time function. We then introduce a scheduling scheme using a linear over-approximation of the predicted completion time function. Using these two schemes, we emulate the operation of the constellation in this task on a network of Raspberry Pi single-board computers, with communication and computation parameters determined by a simulation of the constellation. The results are compared with an emphasis on scheduling performance in terms of the image processing latency.