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ENABLING WORLDWIDE AND TRANSPARENT SPACE TRAFFIC MANAGEMENT THROUGH
DECENTRALIZED AND TRUSTWORTHY SPACE DOMAIN AWARENESS

Abstract

This paper provides an end-to-end framework for decentralized Space Domain Awareness (SDA) that enables worldwide Space Traffic Management (STM), where in the interest of tracking potential threats to on-orbit space systems, all nations and stakeholders undergo the open, immutable, and transparent exchange of SDA data. Key to STM is the timely and reliable transmittal of information including state updates, maneuver alerts, conjunction warnings and any data to support safe operations of near and deep space activities. The United States and Russia are the only two nations with independent end-to-end SDA architecture while others have and continue to invest in local sensor networks. The Space Data Association is the closest example of collecting SDA information in a centralized manner and disseminating risk assessments to its members while the European Union represents the closest example of a multinational exchange and fusion of SDA data. We address three conditions to make the proposed universal STM concept viable: (1) a data validation system that handles the volume and velocity of data delivered from a variety of sensors while establishing its astrometric veracity, (2) a trust-based scheme that leverages Blockchain technology to allow independent nodes or members who maintain a Peer-to-Peer (P2P) network to validate transactions (i.e. space object information updates) and perform consensus on blocks of transactions, and (3) a message handling system where the concept of Notice to Space Operators (NOTSO) is used between members to notify and openly exchange the assumptions, measurements, and imminent behaviors required to characterize a space object. Thus, exchanging SDA data, validating it, and using Blockchain technology enables decentralized participants to provide trustworthy contributions to characterize the life of a space object from launch to deorbit. In turn, a novel concept of performing “space object event forensics” is introduced that opens an avenue to enable STM policy and SDA sustainability. Key metrics that gauge the performance of the proposed framework are identified and examples are provided for representative use cases.