Paper ID: 7151
student

SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Near-Earth and Interplanetary Communications (5)

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EFFICIENT ROUTING IN DISRUPTION-TOLERANT SPACECRAFT NETWORKS

Abstract

In order to meet their mission objectives, future space exploration missions will require a sophisticated and interconnected communication architecture in space. Their networking requirements will be of increased complexity, thus imposing the need for an autonomous and dynamic networking model that can cope with the special environmental conditions met in space. The space environment is characterized by very long distances and environmental hazards that affect a spacecraft network's connectivity and communication efficiency by introducing long propagation delays, intermittent connectivity, and unpredicable communication failures. A spacecraft network that operates under these conditions can be categorized as a Delay Tolerant Network (DTN). We use the Predicable Link State Routing (PLSR) protocol, and enhance it to cope with these extreme DTN networking conditions. PLSR is a routing protocol that is designed to take advantage of the dynamic but predictable spacecraft network topology and to ensure an efficient routing under these conditions. In its current form however, PLSR cannot deal with intermittent connectivity as it appears in a DTN. We develop PLSR-DTN, an efficient enhancement of PLSR that can cope with the intermittent connectivity and that allows efficient routing in future spacecraft networks. Our approach is to provide a DTN functionality only to these network nodes that are establishing DTN links and that are responsible of maintaining an end-to-end connectivity. More concretely, we employ a store-and-forward scheme, which utilizes these DTN nodes to forward their packets to their destination in a hob-by-hop manner, when link connectivity is reestablished. Furthermore, we create and prove correct an algorithm that enhances the efficiency of DTN routing over multiple DTN links. Finally, we develop a realistic spacecraft application scenario, which we use to run simulations with the PLSR and PLSR-DTN protocols by using various network topology configurations under nominal conditions (i.e no unpredictable changes taking place). We show that PLSR-DTN outperforms PLSR, as well as traditional routing protocols, in terms of efficient packet delivery.Our work is of great significance as it delivers to the space community an autonomous, next-generation spacecraft network protocol, equipped with a store-and-forward functionality in order to cope with the problems that are imposed by the special conditions that exist in a disrupted tolerant spacecraft network.