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DYNAMIC PATHFINDING: TIME-VARIANT ROUTING STRATEGIES FOR INTERPLANETARY COMMUNICATIONS

Abstract

Interplanetary Networks (IPNs) are being designed to enable networked communications across astronomical distances. These networks will be challenged by latencies and disconnectivities at scales that break traditional networking algorithms. In some cases, the sources and destinations of messages may not exist in the IPN at the same time. In other cases, there might never be a contemporaneous set of links making a path between the two. Therefore, novel networking algorithms are necessary to construct time-variant paths from predicted sets of future, ephemeral link opportunities called contacts. Algorithms designed for this purpose must distribute these contacts across the network. Nodes in an IPN collect these distributed contacts into a locally stored Contact Collection Buffer (CCB). Prototype algorithms exist to produce time-variant paths given a CCB, but mechanisms for the secure population, inspection, and maintenance of the CCB are incomplete. Authorized access to contacts is important because they can be used to infer information related to the power, activity, and orientation of one or more spacecraft. Due to the sensitive nature of this information, operations related to the CCB must be moderated. There is no current architecture for the secure, regulated distribution of contacts. This paper proposes such an architecture with the following attributes. The data model of a contact must be augmented to not only provide information necessary for time-variant routing algorithms, but to also include methods for accessibility and authorization. Routing algorithms must be augmented to provide credentials when querying the CCB. Integrity mechanisms must be augmented to ensure contact information only comes from authorized sources. Distribution mechanisms must be augmented to consider the local, regional, and universal uses of contact information in the context of regulations and governance models. The future of interplanetary networking depends on trusted information exchange. Absent mechanisms for secure and moderated contact distribution, the operational configuration of an IPN will falter. This is particularly true as the number of spacecraft, administrative domains, and state actors in an IPN grows. This paper identifies these necessary mechanisms and explains how they integrate into a sustainable, scalable architecture.
Keywords: Time-Variant Routing, Contact Graph Routing (CGR), Delay-Tolerant Networking (DTN), Interplanetary Communication Networks