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DESIGNING CUSTODY TRANSFER FOR INTERPLANETARY NETWORKS

Abstract

Interplanetary Networks (IPNs) inclusive of the moon, Mars, and other celestial bodies are being built in cooperation with multiple national space agencies, industry, and academia. By their nature, these networks will be partitioned as a consequence of link delays and disruptions in ways that break traditional networking protocols. Importantly, end-to-end retransmission approaches in a frequently partitioned network are unlikely to succeed, and user reliability is diminished.

New store-and-forward protocols, such as the Bundle Protocol, have been developed to make IPNs more reliable for their users. The new capabilities inherent in these protocols can be used to implement new approaches that increase network resiliency. One promising approach is that of custody transfer.

Custody transfer takes advantage of store-and-forward protocols by assigning a custodian as the entity responsible for retransmitting a message at intermediate nodes in the network. Terrestrial networks do not define a special custodian because they always retransmit data from the message source. Meanwhile, IPNs benefit from progressively updating the custodian to be incrementally closer to the message destination. When a message is retransmitted closer to its destination, there is less likelihood that the message will be further delayed or disrupted.

Currently, there is no standardized mechanism for implementing custody transfer. Multiple organizations, including the Internet Engineering Task Force and the Consultative Committee for Space Data Systems, are proposing different methods, and no method appears to be sufficient for all use cases. Complicating issues include how custody might be requested and subsequently acknowledged; how custodians handle security, fragmentation, and route computations; and what guarantees must be made by links in the network.

Rather than maintaining the view that custody transfer is a single technique, we instead define it as an emergent property of multiple cooperating mechanisms. In doing so, we specify the reliability goals and challenges inherent in IPNs and describe the contributing networking mechanisms. Finally, we provide use cases showing how these mechanisms result in network resiliency and user reliability in the context of a multi-stakeholder cislunar environment.

Custody transfer is a crucial concept for the proper operation of IPNs as it enables network resiliency in highly disrupted environments. By redefining custody transfer as an emerging property of cooperating mechanisms and not a singular method itself, we solve the problem of how this capability can be standardized and implemented in multi-stakeholder IPNs.