Design and Architecture of the Relay Link Analysis Tool

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Unlike a point-to-point communication link, a relay link consists of a concatenation of links, in which the data transfer mechanism can be either real-time or store-and-forward. In addition to topological relationship, time relationship between links becomes an important factor in the overall efficiency of data transfer. The time relationship is depicted using concurrent timeline analysis and visualization. The current Mars relay scenario involves 3 kinds of links: landing asset to orbiter link, orbiter to Earth link, and landing asset to Earth link. In the future we might want to consider two more types: orbiter to orbiter link and landing asset to landing asset. We envision that the landing assets would have simultaneous visibility with multiple orbiters and/or Earth with different degrees of link efficiency. When cast into a network problem that involves multiple landing assets, multiple orbiters, and multiple Earth stations, the overall network efficiency would depends on the planning and scheduling of different types of link.

In this paper we describe the design approach and architecture of the relay link analysis tool that addresses the above operation scenario. We address the following aspects of the design:

Architecture – We describe a client/server architecture to support interactive, batch, WEB, and distributed simulation applications for the relay link analysis scheme. This architecture de-couples visualization, computation, and database functions to allow plug-and-play of various functions and extensions.

Modeling – We describe 3 types of modeling in this scheme:

- Modeling of static link performance (traditional link analysis)
- Modeling link performance during dynamic spacecraft events that include spacecraft's dynamic orbits, spacecraft attitude heuristics (spinning and coning of spacecraft primary and secondary axes), and mobile surface element's orientation and tilt.
- Modeling constraints which include geometric constraints, navigation requirements, mission activities, time constraints, flight rules/mission rules, policy constraints, and human factors

Design automation and resource optimization – We describe the following two methods:

- Constraint-driven and link-capability-driven planning and scheduling as a constrained optimization problem.
- Providing hooks for relay planning and scheduling using commercial off-the-shelf (COTS) tools like ILOG and MATLAB and JPL in-house planning tools such as ASPGEN, ASPEN, and TIGRES.