Next Generation Telecom Web Services for Cubesat Scheduling

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Abstract

Mission Operations Web Services Concept

In this study we describe a software architecture to deliver tools for rapid spacecraft (or CubeSat) planning and scheduling with applicability to design and analysis. We implemented web-based mission operations services to analyze potential scheduling opportunities using Representational State Transfer (REST) Application Programming Interfaces (APIs) for (1) geometric visibility analysis and (2) link budget analysis. These APIs can be made available for other software tools to use, and we have prototyped modular use of these APIs with visualization tools and Liferay portlets. We estimate link performances for various cubesat radio transceiver profiles from different ground antennas over various time frames and evaluate different scheduling opportunities, taking into account both geometric visibility and recommended data rates. Future plans include analyzing tradeoff opportunities for multiple cubesats to make optimal use of limited communications network access.

Objectives

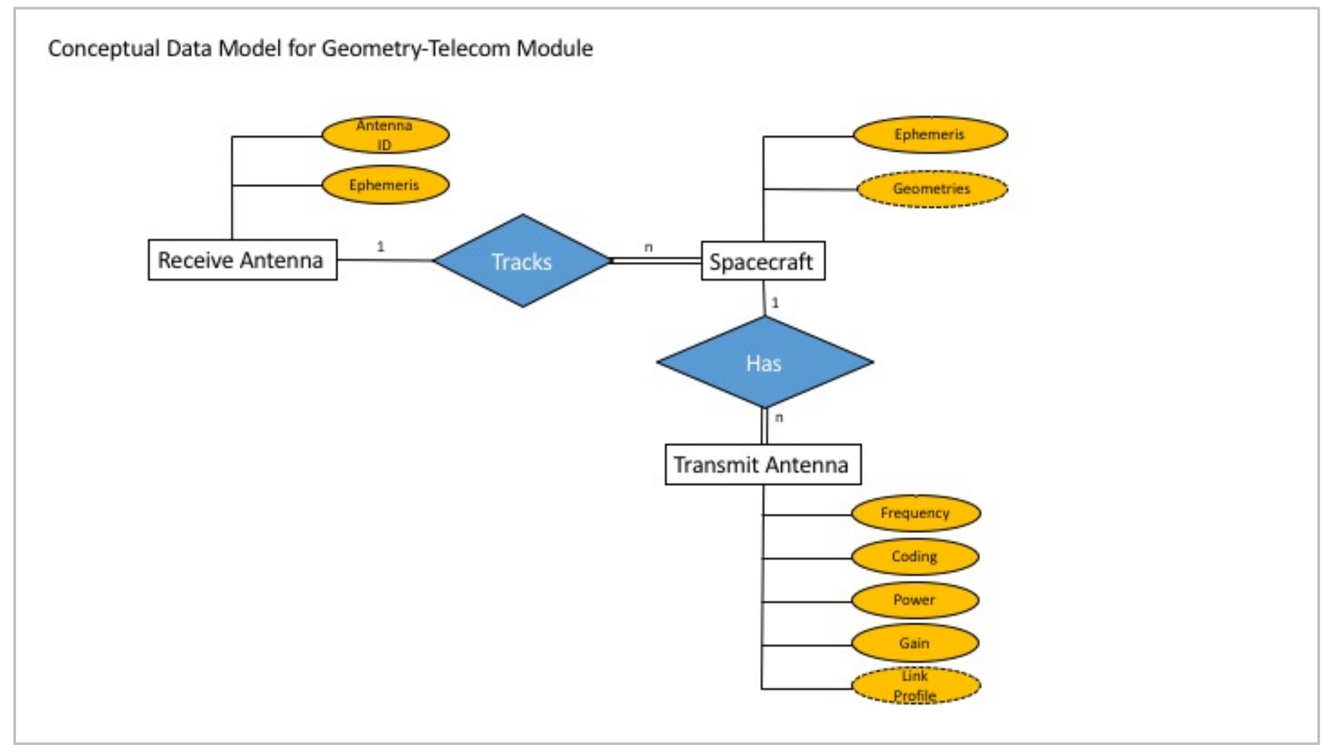
Technical Contributions to Mission Operations

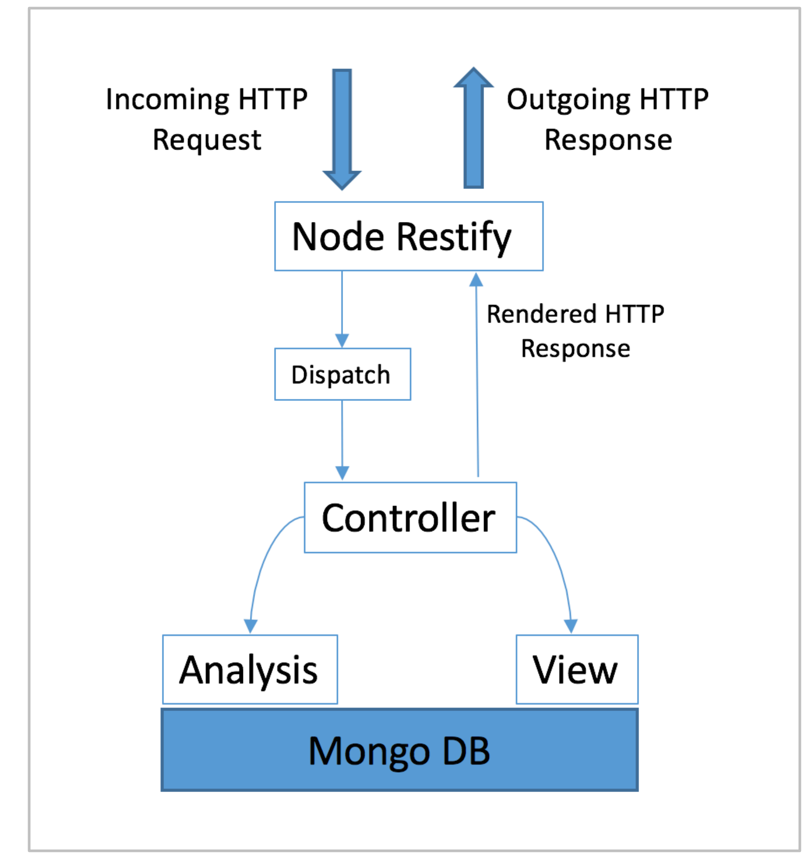
- Enable interoperability between users and agencies.
- Facilitate rapid mission planning and scheduling.
- Allow re-use between missions and ground systems.
- Make available commercial generic tools.
- Use modular components to replace implementation technology without major system redesign.
- Establish common concepts across mission systems to support rapid mission integrations.
- Single adapter and common service layer for all missions.

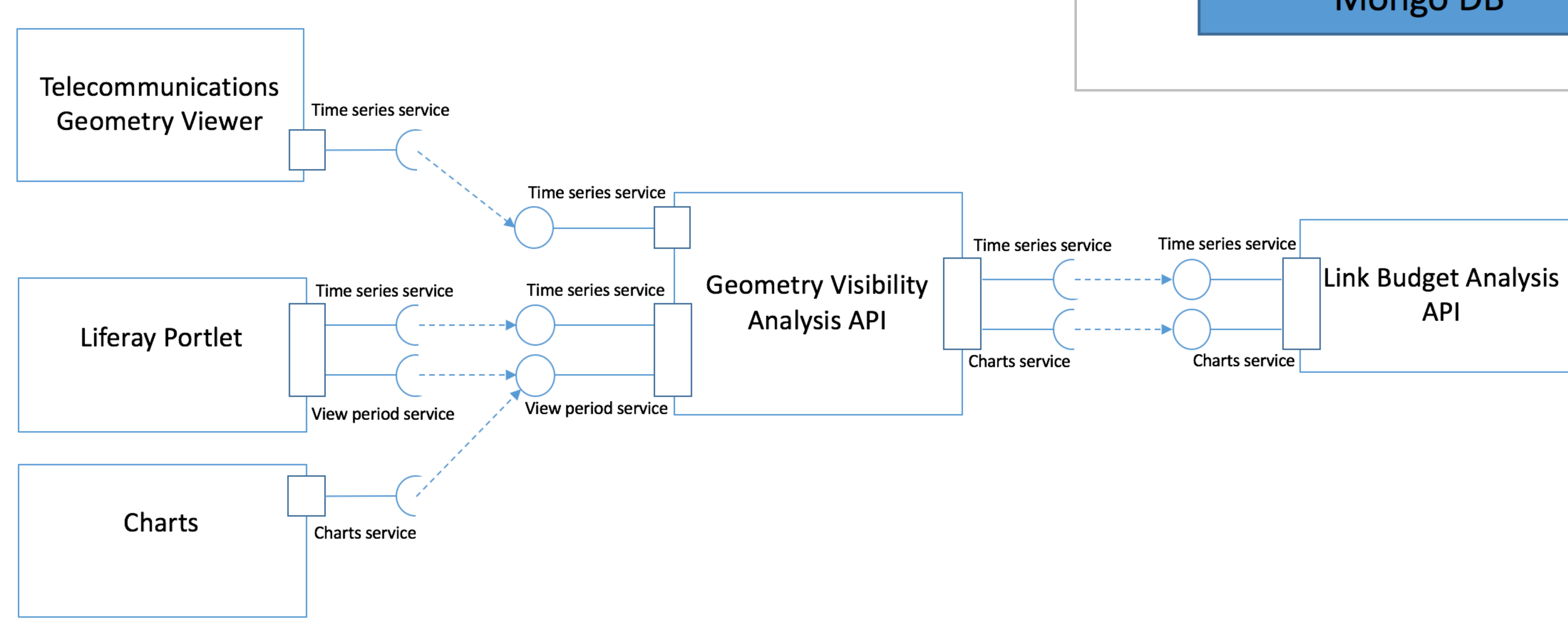
Software Engineering Advantages

- Improved scalability of development processes. Modules can be integrated with network applications of varying size.
- Includes framework for system and subsystem testing.
- Components permit for reuse and encourage consistency.
- Supports iterative development.

Architecture





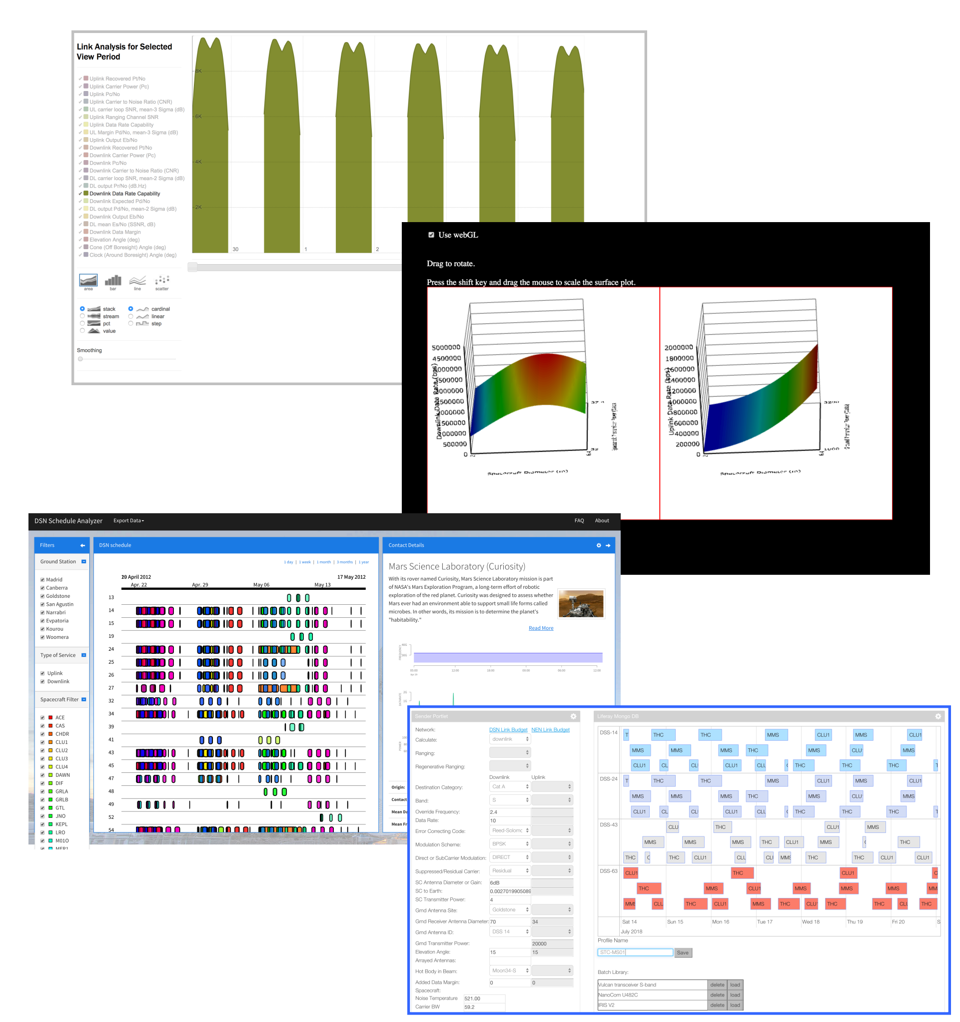


Description of Architecture

- Conceptual Data model addresses end-to-end interaction between applications for the space and ground segments. Using this model we can describe a variety of transport services and communication paths.
- Service Framework follows the principles of Representational State Transfer (REST) Service Oriented Architectures.
- Message Abstraction Layer helps manage data flow between entities. Geometry visibility analysis is an extension of link budget analysis and are linked together to provide functions that provide better insight into link and visibility opportunities.

Integration with Visualization Tools

- Rickshaw chart plots supportable data rates over time.
- WebGL (Web Graphics Library) JavaScript API renders 3-d surface plot of data rates based on antenna diameter and transmitter power.
- D3 Data Driven Documents draws antenna schedule and plots for spacecraft view periods.
- Vis.js timeline supports manipulation of and interaction with the data.



Demonstration

Technologies Used

- SPICE toolkit used to analyze geometries.
- Single point link analysis calculator analyses link budget.
- Node.js framework used to make tools asynchronous and event driven for network applications.
- Restify allows for control over interactions with HTTP and full observability into latency and characteristics of applications.
- Mongodb gridfs stores data into small, manageable chunks for access. Keeps ephemeris files and metadata automatically synced across a number of systems and facilities.
- Mongoose for creating object models.

Future Work

- Assess Quality of Service.
- Define standards for exposed interfaces between applications.
- Develop benchmarking framework for testing and to evaluate efficiency.
- Implement support for maintenance and use.

References

1. Mission Operations Services Concept. Green Book. Issue 3. December 2010. http://public.ccsds.org/publications/archive/520x0g3.pdf
2. Mission Operations Services Concept. MagentaBook. Issue 1. July 2010. http://public.ccsds.org/publications/archive/520x0g3.pdf
3. Mark Johnston, Butch Carruth, Michael Wallace, Adam Coffman, Carlyn-Ann Lee, Chi-Wung Lau, Kar-Ming Cheung, and Michael Levesque. *"Integrating Space Communication Network Capabilities via Web Portal Technologies"*, SpaceOps 2014 Conference, SpaceOps Conferences, (AIAA 2014-1601).

Resources

- Service Preparation Subsystems Portal: https://spsweb.fltops.jpl.nasa.gov
- SPICE Toolkit: https://naif.jpl.nasa.gov
- Nodejs: https://nodejs.org
- Restify framework: https://github.com/restify/node-restify
- Mongodb: https://docs.mongodb.org/
- D3 Data Driven Documents: https://d3js.org/
- Rickshaw Charts: http://code.shutterstock.com/rickshaw/
- Webgl surface plots: https://www.npmjs.com/package/gl-surface-plot
- Vis.js library: http://visjs.org/
- Geometry-telecom project: github.jpl.nasa.gov/carlynan/geometry-telecom/