Distributed Engine Control Empirical/Analytical Verification Tools

Key factors such as control system performance, reliability, weight, and bandwidth utilization can be systematically assessed.

John H. Glenn Research Center, Cleveland, Ohio

NASA's vision for an intelligent engine will be realized with the development of a truly distributed control system featuring highly reliable, modular, and dependable components capable of both surviving the harsh engine operating environment and decentralized functionality. A set of control system verification tools was developed and applied to a C-MAPSS40K engine model, and metrics were established to assess the stability and performance of these control systems on the same platform. A software tool was developed that allows designers to assemble easily a distributed control system in software and immediately assess the overall impacts of the system on the target (simulated) platform, allowing control system designers to converge rapidly on acceptable architectures with consideration to all required hardware elements. The software developed in this program will be installed on a distributed hardware-in-the-loop (DHIL) simulation tool to assist NASA and the Distributed Engine Control Working Group (DECWG) in integrating DCS (distributed engine control systems) components onto existing and next-generation engines.

The distributed engine control simulator blockset for MATLAB/Simulink and hardware simulator provides the capability to simulate "virtual" subcomponents, as well as swap actual subcomponents for hardware-in-the-loop (HIL) analysis. Subcomponents can be the communication network, smart sensor or actuator nodes, or a centralized control system. The distributed engine control blockset for MATLAB/Simulink is a software development tool. The software includes an engine simulation, a communication network simulation, control algorithms, and analysis algorithms set up in a modular environment for rapid simulation of different network architectures; the hardware consists of an embedded device running parts of the C-MAPSS engine simulator and controlled through Simulink.

The distributed engine control simulation, evaluation, and analysis technology provides unique capabilities to study the effects of a given change to the control system in the context of the distributed paradigm. The simulation tool can support treatment of all components within the control system, both "virtual" and real; these include communication data network, smart sensor and actuator nodes, centralized control system (FADEC — full authority digital engine control), and the aircraft engine itself. The DECsim tool can allow simulation-based prototyping of control laws, control architectures, and decentralization strategies before hardware is integrated into the system. With the configuration specified, the simulator allows a variety of key factors to be systematically assessed. Such factors include control system performance, reliability, weight, and bandwidth utilization. The ability to provide a configurable, high-fidelity distributed engine control simulation, control system analysis, and HIL evaluation is a unique capability of the technology.

This work was done by Jonathan DeCastro and Eric Hettler of Impact Technologies, LLC; Rama Yedavalli of the Ohio State University; and Sayan Mitra of the University of Illinois at Urbana for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18829-1.

Dynamic Server-Based KML Code Generator Method for Level-of-Detail Traversal of Geospatial Data

Innovation uses a C- or PHP-code-like grammar that provides a high degree of processing flexibility.

Stennis Space Center, Mississippi

Geospatial data servers that support Web-based geospatial client applications such as Google Earth and NASA World Wind must listen to data requests, access appropriate stored data, and compile a data response to the requesting client application. This process occurs repeatedly to support multiple client requests and application instances. Newer Web-based geospatial clients also provide user-interactive functionality that is dependent on fast and efficient server responses. With massively large datasets, server-client interaction can become severely impeded because the server must determine the best way to assemble data to meet the client applications request. In client applications such as Google Earth, the user interactively wanders through the data using visually guided panning and zooming actions. With these actions, the client application is continually issuing data requests to the server without knowledge of the server's data structure or extraction/assembly paradigm.

A method for efficiently controlling the networked access of a Web-based geospatial browser to server-based datasets — in particular, massively sized datasets — has been developed. The method specifically uses the Keyhole Markup Language (KML), an Open Geospatial Consortium (OGS) standard used by Google Earth and other KML-compliant geospatial client applications. The innovation is based on establishing a dynamic cascading KML strategy that is initiated by a KML launch file provided by a data server host to a Google Earth or similar KML-compliant geospatial client application user. Upon execution, the launch KML code issues a request for image data covering an initial geographic region. The server responds with the requested data along with subsequent dynamically generated KML code that directs the client application to make follow-on requests for higher level of detail (LOD) imagery to replace the initial imagery as the user navigates into the dataset. The approach provides an efficient data traversal path and mechanism that can be flexibly established for any dataset regardless of size or other characteristics. The method yields significant improvements in user-interactive geospatial client and data server interaction and associated network bandwidth requirements.

The innovation uses a C- or PHP-code-like grammar that provides a high degree of processing flexibility. A set of language lexer and parser elements is provided that offers a complete language grammar for writing and executing language directives. A script is wrapped and passed to the geospatial data server by a client application as a component of a standard KML-compliant statement. The approach provides an efficient means for a geospatial client application to request server preprocessing of data prior to client delivery.

Data is structured in a quadtree format. As the user zooms into the dataset, geographic regions are subdivided into four child regions. Conversely, as the user zooms out, four child regions collapse into a single, lower-LOD region. The approach provides an efficient data traversal path and mechanism that can be flexibly established for any dataset regardless of size or other characteristics.

This work was done by Gregory Baxes, Brian Mixon, and Tim Linger of TerraMetrics, Inc. for Stennis Space Center. For more information call the SSC Center Chief Technologist at (228) 688-1929. Refer to SSC-00362/5.

Automated Planning of Science Products Based on Nadir Overflights and Alerts for Onboard and Ground Processing

NASA's Jet Propulsion Laboratory, Pasadena, California

A set of automated planning algorithms is the current operations baseline approach for the Intelligent Payload Module (IPM) of the proposed Hyperspectral Infrared Imager (HyspIRI) mission. For this operations concept, there are only local (e.g. non-depletable) operations constraints, such as real-time downlink and onboard memory, and the forward sweeping algorithm is optimal for determining which science products should be generated onboard and on ground based on geographical overflights, science priorities, alerts, requests, and onboard and ground processing constraints.

This automated planning approach was developed for the HyspIRI IPM concept. The HyspIRI IPM is proposed to use an X-band Direct Broadcast (DB) capability that would enable data to be delivered to ground stations virtually as it is acquired. However, the HyspIRI VSWIR and TIR instruments will produce approximately 1 Gbps data, while the DB capability is 15 Mbps for a ≈60× oversubscription. In order to address this mismatch, this innovation determines which data to downlink based on both the type of surface the spacecraft is overflying, and the onboard processing of data to detect events. For example, when the spacecraft is overflying Polar Regions, it might downlink a snow/ice product. Additionally, the onboard software will search for thermal signatures indicative of a volcanic event or wild fire and downlink summary information (extent, spectra) when detected, thereby reducing data volume. The planning system described above automatically generated the IPM mission plan based on requested products, the overflight regions, and available resources.

This work was done by Steve A. Chien, David A. McLaren, and Gregg R. Rabideau of Caltech; Daniel Mandl of NASA Goddard Space Flight Center; and Jerry Hengemihle of Microtel LLC for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47875

Linked Autonomous Interplanetary Satellite Orbit Navigation

Single satellite can track another satellite elsewhere in the Earth-Moon system and obtain absolute knowledge of both satellites' states.

NASA's Jet Propulsion Laboratory, Pasadena, California

A navigation technology known as LiAISON (Linked Autonomous Interplanetary Satellite Orbit Navigation) has been known to produce very impressive navigation results for scenarios involving two or more cooperative satellites near the Moon, such that at least one satellite must be in an orbit significantly perturbed by the Earth, such as a lunar halo orbit. The two (or more) satellites track each other using satellite-to-satellite range and/or range-rate measurements. These relative measurements yield absolute orbit navigation when one of the satellites is in a lunar halo orbit, or the like.

The geometry between a lunar halo orbiter and a GEO satellite continuously changes, which dramatically improves the information content of a satellite-to-satellite tracking signal. The