Mission Operations Control Applications (MOCA) – Near real-time state models

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Innovation

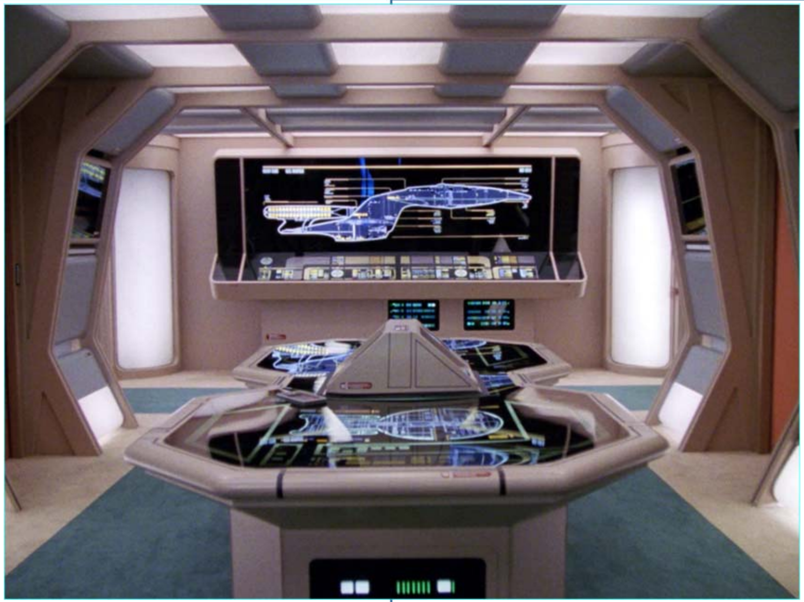
(1) Create an intelligent autonomous agent cognitive architecture that is both open and modular using near real-time state models that allows for a mutable locus of control between remote operators, on board crew (if applicable), and autonoma on a shared basis. The architecture must support Mission Operations Control Applications (MOCA) that can be feasibly certified for use on ISS, Cislunar, and deep space missions for both payload and spacecraft operations.
(2) Implement the cognitive architecture as MOCA in support of one or more Technology Development, Demonstration, and Deployment (TD^3) missions including overlays for:
-- Enabling technology for virtual operations centers for Cubesats/Smallsats (ACS),
-- Frequency agnostic space-to-space power and ancillary services beaming (SSPB),
-- Interoperable Network Communication Architectures (INCA) implementing, dynamically allocated Quality of Service (QoS) based routing/relays/switching,
-- Advanced Vision and Task Area Recognition (AVaTAR) for EVA & IVA robotic systems, as well as proof-of-concept protoflight code base (TRL 4/5) for at least SSPB TD^3 mission.
(3) Establish that intelligent autonomous agents implemented as MOCA can be used to virtualize functions that allow for the specification and shared control of systems-of-systems based on QoS requirements (i.e., performance, availability, and security).

Technical Approach

(1) Develop near real-time state model extensions to the NASA Ames Mission Control Technologies (Open MCT) software platform, using the hypothesized XISP-Inc Xrosslink Protocol which allows systems-of-systems problems to be modeled as a set of defined flows (Energy, Information, Matter) with specified attributes frames across all known interfaces within a defined problem space.
(2) MOCA solution spaces are created and bounded by propagating constraints faster for a particular problem subset than a given problem space is changing.
(3) Work plan entails incremental, iterative, and recursive development of near real-time state models of all the supported TD^3 mission components operating within the MCT framework with particular emphasis on the SSPB mission and its synergy with others. For Phase I the scope of the work includes: conceptual intelligent autonomous agent cognitive architecture defined with MOCA overlays for the supported TD^3 missions to characterize the problem space; preliminary architecture implementation with multiple near real-time state models for at least one TD^3 mission (SSPB) to characterize the solution space; and, detailed implementation of a MOCA overlay demonstrating near real-time shared control for at least one TD^3 mission (SSPB) to provide a protoflight proof-of-concept.

Potential & Benifits

(1) MOCA implementation significantly advances the state-of-the-art (TRL 2 to 4/5) and can be further developed to (TRL 7/8) so as to be mission enhancing if not mission enabling for myriad of forthcoming Cislunar and beyond missions.
(2) MOCA implementation allows more to be accomplished with less ground, crew, and flight resources by virtualization and QoS optimization.
(3) MOCA implementation enables shared control between remote operators, crew and autonoma.
(4) MOCA implementation helps mitigate cost, schedule, and technical risk by increasing failure tolerance, resilience, and maintainability of complex systems-of-systems.
(5) MOCA implementation enables interoperability and provides for mutable layered control.
(6) Advancing MOCA TRL to allow for its implementation and ubiquitous use will help foster an ecosystem of cooperating Cislunar companies.



Star Trek artwork envisioning starship control ©CBS,
Actualization of MOCA by XISP-Inc is pending!

Evaluation Notes

Mission Operations Control Applications -- Near real-time state models XISP-Inc Technical & Management Proposal NIAC Phase I Proposal

I. MISSION OVERVIEW

The Problem

Systems-of-systems state models are N-Dimensional interaction problems (i.e., a potentially arbitrary number of objects interacting in an arbitrary number of ways), a class of problems for which the generalized solution space is typically computationally intractable in any time frame. Space automation, autonomy, and robotics present a subset of these problems that exacerbates the situation by requiring near real-time solutions in many instances. Evolving mission requirements for enabling shared control between remote operators, crew and autonoma will be increasing critical for Cislunar and beyond missions. Solving these challenges requires the ability to structure and order complex knowledge sets in both a computationally tractable manner and in a framework coherent and accessible to human understanding. Fundamentally, reality is neither a convenient problem nor solution space.

Innovation

XISP-Inc proposes to create an intelligent autonomous agent cognitive architecture that is both open and modular using near real-time state models that allows for a mutable locus of control between remote operators, on board crew (if applicable), and autonoma on a shared basis. The architecture includes a combination of a conceptual framework for structuring and ordering the domain knowledge bases and their relationships, a Xrosslink protocol for mapping and coding those relationships, the software and hardware requirements for implementing the same, and the meta data/operational rules for controlling the applicable system-of-systems. The architecture must support Mission Operations Control Applications (MOCA) that can be feasibly certified for use on ISS, Cislunar, and deep space missions for both payload and spacecraft operations. The proposed innovation will be actualized using the XISP-Inc developed Xrosslink Protocol implement MOCA within the NASA Ames Mission Control Technologies (Open MCT) software platform, in support of one or more Technology Development, Demonstration, and Deployment (TD^3) missions. The objective is to create an extensible implementation tool set for near real-time state models that can be applicable to multiple TD^3 missions.

XISP-Inc proposes to implement the cognitive architecture as MOCA in support of one or more Technology Development, Demonstration, and Deployment (TD^3) missions including but not limited to overlays for:

-- Enabling technology for virtual operations for Alpha Cube Sat (ACS) and others,
-- Frequency agnostic Space-to-Space Power Beaming (SSPB) and ancillary services,

-- Interoperable Network Communication Architectures (INCA) implementing, dynamically allocated Quality of Service (QoS) based routing/relays/switching,
-- Advanced Vision and Task Area Recognition (AVaTAR) for EVA & IVA robotic systems.
This will work will evolve into a proof-of-concept protoflight code base (TRL 4/5) for at least the SSPB TD^3 mission as well a comparison and assessment of alternate means of satisfying the requirements (where it is possible to do so). XISP-Inc will seek to establish that intelligent autonomous agents implemented as MOCA can be used to virtualize functions that allow for the specification and shared control of systems-of-systems based on QoS requirements (i.e., performance, availability, and security).

II. TECHNICAL OVERVIEW

Technical Approach

XISP-Inc shall develop near real-time state model extensions to the NASA Ames Mission Control Technologies (Open MCT) software platform, using the hypothesized XISP-Inc Xrosslink Protocol which allows systems-of-systems problems to be modeled as a set of defined flows (Energy, Information, Matter) with specified attributes frames across all known interfaces within a defined problem space. The MOCA solution spaces are created and bounded by propagating constraints faster for a particular problem subset than a given problem space is changing. The work plan entails incremental, iterative, and recursive development of near real-time state models for all the supported TD^3 mission components operating within the Open MCT framework / environment with particular emphasis on the SSPB mission and its synergy with others.

Potential & Benefits

The MOCA implementation proposed significantly advances the state-of-the-art (TRL 2 to 4/5) and if done now can allow for the timely further development to (TRL 7/8) so as to be mission-enhancing if not mission-enabling for the myriad of forthcoming Cislunar (LEO to Lunar Surface) and beyond missions. MOCA will allow more to be accomplished with the parsimonious use of ground, crew, and flight resources by virtualization and QoS optimization. MOCA enables shared control between remote operators, crew and autonoma. MOCA will help mitigate cost, schedule, and technical risk by increasing failure tolerance, resilience, and maintainability of complex systems-of-systems. MOCA enables interoperability and provides for mutable layered control. Advancing MOCA TRL to allow for its implementation and ubiquitous use will help foster an ecosystem of cooperating Cislunar companies and foster additional NASA missions.

For Phase I the scope of the work includes:
-- Conceptual intelligent autonomous agent cognitive architecture defined with MOCA overlays for the supported TD^3 missions to characterize the problem space.
-- Preliminary architecture implementation with multiple near real-time state models for at least one TD^3 mission (SSPB) to characterize the solution space.
-- Detailed implementation of a MOCA overlay demonstrating near real-time shared control for at least one TD^3 mission (SSPB) to provide a protoflight proof-of-concept.
The Phase I deliverables will include NIAC Fellow participation in the two required program meetings (i.e., Orientation, NIAC Symposium), quarterly brief written status reports, and a final written publically releasable technical report which includes the detailed: concept and benefits, mission analysis, technical approach, technical feasibility findings, technical challenges that remain to be addressed, and a proprietary appendix (if applicable).

The cognitive architecture will be designed for implementation as a set of virtualized functions with defined Quality of Service (QoS) requirements. It will be capable of supporting multiple processes executing on multiple processors, in order to meet the expected computational loads as well as be robust to processor failure. The cognitive architecture developed will be capable of being certified for crew support on spacecraft and will be open to NASA with interfaces open to NASA partners who develop modules that integrate with other modules on the cognitive agent in contrast to proprietary black-box agents. The proposed research program while anticipated to be tractable is at best on the bleeding edge of the state-of-the-art. Demonstrating a cognitive architecture that supports one or more practical applications in a tractable manner that can at least provide satisfactory and sufficient control authority with a mutable locus of control is a technology development challenge. Accordingly, rather than treat this is an abstract problem XISP-Inc proposes to use this effort to focus on the development of near real-time models that can satisfy the mission requirements of the XISP-Inc integrated ISS TD^3 mission set moving forward under an evolving set public-private partnerships.

III. MANAGEMENT OVERVIEW

XISP-Inc.'s corporate mission is to form extraordinary innovative space public/private partnerships to further the development of innovative technology and applications, useful for space exploration and development as well as terrestrial markets. XISP-Inc founder, President and CEO; Gary Pearce Barnhard, a robotic space systems engineer with a wide range of computer, robotic, and space systems engineering experience (~41 years) is the sole owner and proposed NIAC Fellow for this proposal. This work would be managed and performed by XISP-Inc, with the Mr. Barnhard personally leading the study effort and serving as integral part of the work product generation team. XISP-Inc will leverage the fully equipped and functioning office environment outfitted for up to five people with ~1 GB symmetric internet connectivity (~1,600+ Sq.ft custom office suite) provided by Barnhard Associates, LLC (BALLC). BALLC is a systems engineering consulting, Value Added Reseller, Internet Service Provider, and Managed Service Provider which is collocated with XISP-Inc. Accordingly, XISP-Inc has all the necessary instrumentation and facilities to be used to perform the proposed work.

IV. REFERENCES

The following references include presentations and papers germane to the development of the foundational technology, as well as the related and allied mission development work. All of these references are available on the www.xisp-inc.com web site in additional to the listed source (as applicable).

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