Controlling Multiple Satellite Constellations Using the TEAMAgent System

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1   Introduction

There is an increasing desire in many organizations, including NASA, to use constellations or fleets of autonomous spacecraft working together to accomplish complex mission objectives. Coordinating the activities of all the satellites in a constellation is not a trivial task, however.

The TEAMAgent system is being developed under a Phase II SBIR contract from the Surveillance and Control Division of the Air Force Research Laboratory's Space Vehicles Directorate to address this issue. The TEAMAgent system is an extension of the ObjectAgent software architecture to constellations of multiple spacecraft. The required spacecraft functions for the multiple spacecraft missions have been identified and the use of software agents and multi-agent based organizations to satisfy these functions have been demonstrated. TEAMAgent is presently being ported from Matlab to C++ for implementation on a real-time system.

2   The ObjectAgent Software Architecture

ObjectAgent is a new software architecture for real-time systems which require complex autonomous decision making as part of their normal operations. Agents are used to implement all of the software functionality and communicate through messages using a simplified natural language, which enables end-users to easily understand and command them. Decision-making and fault detection and recovery capabilities are built-in at all levels of the software, which alleviates the need for extremely intelligent high-level agents. Furthermore, agents can be dynamically loaded at any time, which simplifies the process of updating flight software and removes the complexity associated with software patches.

The ObjectAgent software package provides a graphical user interface (GUI) based development environment for the design and simulation of multi-agent systems. This design environment simplifies the agent creation process and provides a common interface to a number of advanced control and estimation techniques. The Agent Developer GUI is shown in Figure 1.
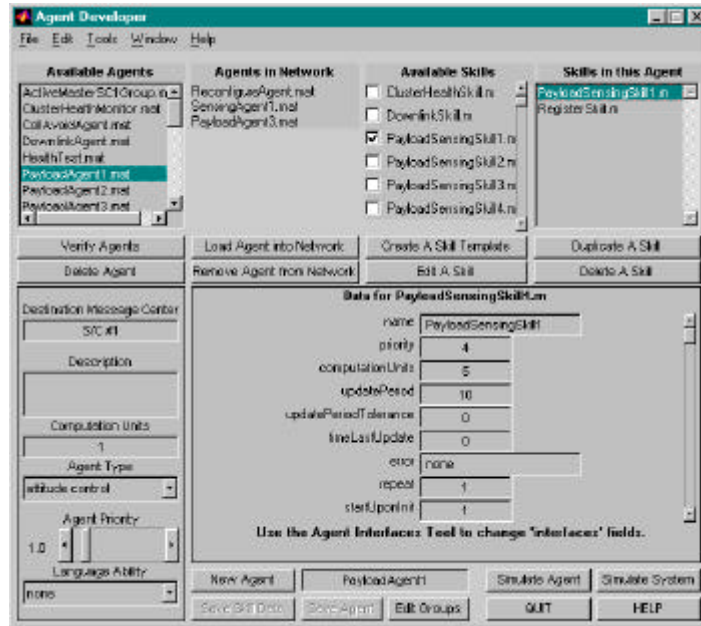
Fig. 1. The Agent Developer GUI allows users to create agents without writing a lot of code.

3   The TEAMAgent System

The TEAMAgent system builds upon ObjectAgent and enables agent-based multi-satellite systems to fulfill complex mission objectives by autonomously making high- and low-level decisions based on the information available to any and/or all agents in the satellite system. This is achieved through the use of hierarchical communication and decision-making paths among the agents that can be autonomously reconfigured as new agents are added and old agents are modified or removed. GUIs enable the satellite end users to initially configure the TEAMAgent system and monitor the effectiveness of the decisions made by the agents.

   Simulations of multi-agent systems for multiple satellites have been developed using TEAMAgent, such as collision avoidance maneuver and reconfiguration for a four-satellite constellation. Agents are used to monitor for collisions, reconfigure the fleet, optimize fuel usage across the cluster during reconfiguration, and develop a fuel optimal maneuver for reconfiguration. These simulations have demonstrated the feasibility of using TEAMAgent to control multiple satellite constellations and TEAMAgent is presently being ported to C++ for implementation on a real-time testbed and satellite system.