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AN ECONOMIC FLAVORED ALGORITHM FOR SPACECRAFT SUBSYSTEM MANAGEMENT AND OPTIMIZATION

Abstract

Modern engineering systems, especially if space-related, are required to perform a multitude of functions, and this often requires complex subsystem interaction. The subsystems, especially when redundancy is present, (and when the same outputs - such as current, fuel, torque - can be obtained through different devices), need to implement a strategy to distribute tasks and resources: to obtain an efficient architecture, optimization strategies must be used.

In this work, in order to achieve a condition of maximum efficiency, we compare the engineering system to an economic marketplace. The system is treated as a closed economy, in which a set of scarce resources need to be allocated to satisfy the requests of the system.

By implementing a game of direct competition among fictitious agents (which control the different subsystems), a dynamic equilibrium is eventually reached. Such equilibrium is Pareto efficient according to the first Welfare theorem.

Traditionally, to solve a multiple input-multiple output (MIMO) bounded optimization, one would arbitrarily assign a relative importance among the variables, and then implement classic optimization policies such as Lagrange multipliers. Instead, by using this novel approach, the system can dynamically and automatically change the relative importance of such resources in order to react to both external and internal shocks (drops in solar panel effectiveness, temporary thermal overloads, frozen batteries, locked reaction wheel, etc.). The system becomes adaptive and is therefore more robust and reliable. Modular systems exhibiting a high degree of redundancy can be managed by this economically inspired algorithm to maintain high efficiency within a large realm of environmental conditions and to keep critical functionalities within acceptable performance levels, even against multiple failures.

In this paper, we present the results obtained by applying this novel approach: a simplified satellite mockup is commanded to perform attitude control, thermal monitoring and power management; the dynamic environment was modeled with periodic external solar flux while a tracking maneuver was performed.

Performances were measured as total power consumption and error on temperature and attitude; we introduced some subsystem parameter variations, both by lowering the efficiency of certain components and by completely removing the effect of some of them (as in the case of component failure). A traditional resource management algorithm was used as a benchmark for comparison.

In the simulations, our algorithm always performed better than the traditional one, proving to be a promising technique in the area of system level resource management.