Modeling the Image-processing Behavior of the NASA Voyager Mission with ASSL

Emil Vassev, *Member, IEEE*, Mike Hinchey, *Senior Member, IEEE*

***Abstract* – The Autonomic System Specification Language (ASSL) is used to build a formal model and generate a prototype for the image-processing behavior of the Voyager Mission.**

***Index Terms* – Voyager Mission, ASSL, code generation**

I. Objectives

THE NASA Voyager Mission was designed for exploration of the Solar System. The mission started in 1977, when the twin spacecraft Voyager I and Voyager II were launched. As the Voyagers flew across the Solar System, they took pictures of planets and their satellites. The pictures taken by the Voyagers were transmitted to Earth via radio signals. In order to send pictures to Earth, the spacecraft first filtered images (taken by their cameras) through different color filters and then converted those filtered images into a stream of pixels and sent the same to Earth as radio signals [1].

Although, the Voyager mission to the outer planets is now over, both Voyagers are still healthy and they have been sent on an extended mission to chart the heliopause boundary. This extreme success of the Voyager mission, designed and built over 30 years ago, makes the same a good example for future space missions. Therefore, both prototyping, and formal modeling, which will aid in the design and implementation of future Voyager-like missions, are becoming increasingly necessary and important as the urgent need emerges for high levels of assurance regarding correctness and autonomous behavior persists in the Voyager requirements.

II. Research

The Autonomic System Specification Language (ASSL) [2] is an initiative for self-management of complex systems where we approach the problem of formal specification, validation, and code generation of autonomic systems [3] within a framework.

It is our intent to apply ASSL to build a formal model and generate a prototype for the Voyager mission, thus helping with system validation and further investigation based on practical results under simulated conditions. Knowledge of the success of the Voyager mission enables us to compare issues arising in the mission itself with potential approaches to their mitigation.

In the course of this project, we successfully specified the image-processing behavior of the NASA Voyager Mission with ASSL. Note that the Voyager spacecraft must detect interesting objects and take pictures of the same on-the-fly. This reveals a sort of autonomic event-driven behavior which can be easily specified with ASSL, because the latter exposes a rich set of specification structures allowing specification of self-management policies that form the behavior of autonomic systems in particular event-based situations [2].

III. Results

We applied the ASSL multi-tier specification model to specify the Voyager spacecraft and the antennas on Earth as autonomic elements [3] that follow their encoded autonomic behavior and exchange predefined ASSL messages over predefined ASSL communication channels [2].

Next, we generated a Java prototype of the Voyager Mission and experimented with it to explore important state-transition operations ongoing in the system at run-time and to trace the behavior of the generated system.

IV. Benefits for Space Systems

Both the ASSL model for the Voyager Mission and the prototype of the same can be extremely useful for the design and implementation of future Voyager-like missions in terms of feature validation and experimental results. The ability to compare features and issues with the actual mission and with hypothesized possible autonomic approaches gives significant benefit.

V. Future Work

We intend to complete the ASSL model for the Voyager Mission by adding autonomic features (e.g. self-healing), which should be considered by the new generation of space exploration missions.

References

[1] W. M. Browne, "Technical 'Magic' Converts A Puny Signal Into Pictures", *NY Times*, August 26, 1989.

[2] E. Vassev, Towards a Framework for Specification and Code Generation of Autonomic Systems, Ph.D. Thesis, Department of Computer Science and Software Engineering, Concordia University, Montreal, Canada, November, 2008.

[3] IBM Corporation, "An architectural blueprint for autonomic computing", White paper, 4th ed., 2006.