An Agent Community Supporting Orbit Determination

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Abstract

During the past year we have been engaged in an effort to develop a prototype community of fine-grained agents to support the orbit determination process for the SOHO [1] mission. This paper presents a high-level overview of what was accomplished.

1. Introduction

Figure 1 illustrates the experimental SOHO Orbit Determination (OD) community of fine-grained agents as originally envisioned. The SOHO (Solar & Heliospheric Observatory) project is being carried out by the European Space Agency (ESA) and the US National Aeronautics and Space Administration (NASA) as a cooperative effort between the two agencies in the framework of the Solar Terrestrial Science Program (STSP). SOHO was launched on December 2, 1995. The SOHO spacecraft was built in Europe by an industry team led by Matra, and instruments were provided by European and American scientists. There are nine European Principal Investigators (PI's) and three American ones. Large engineering teams and more than 200 co-investigators from many institutions supported the PI's in the development of the instruments and in the preparation of their operations and

data analysis. NASA was responsible for the launch and is now responsible for mission operations. Large radio dishes around the world, which form NASA's Deep Space Network, are used to track the spacecraft beyond the Earth's orbit. Mission control is based at Goddard Space Flight Center in Maryland.

The purpose of the agent community is to provide orbit determination knowledge to those who request it in the SOHO control center. In addition to collaboration and coordination among themselves, the community is capable of making use of external resources, such as FreeFlyer – a server that provides an orbit determination process, to provide this data and related products in a timely fashion. The agents communicate with each other through FIPA (Foundation for Intelligent Physical Agents) ACL (Agent Command Language) messages and the community interacts with the user through a web-based interface.

The community consists of nine fine-grained agents as briefly described below:

- Supervisor – is charged with controlling and monitoring inter-agent activity. It is responsible for starting and stopping all other agents in the

community. All user commands are sent to the Supervisor via the UIAgent and it is the responsibility of the Supervisor to determine what is done with them. The Supervisor is also responsible for sending all Free Flyer commands to the gateway agent.

- User Interface – acts as a liaison between the agents and the operator. The User Interface receives messages and commands from the user and displays useful and desired information.

- Gateway – establishes and maintains an interface to Free Flyer for use as a resource by the agent community. The Gateway agent passes commands to Free Flyer and Free Flyer data to the agents.

- Process – monitors the orbit determination process performed by the Free Flyer OD process. It is responsible for the reporting of detected process errors to the other agents.

- Solution – accumulates orbit determination knowledge about the spacecraft being monitored - SOHO in our case. Unlike the Process Agent that examines each range residual individually, the Solution Agent simply stores range residuals and displays to the screen through the GUI panel when requested by the user.

- Input – monitors the existence and quality of incoming tracking data files to be used by Free Flyer.

- Distribution – monitors generation and distribution of OD products (e.g. state estimates, ground station pass predicts, etc.)

- UIAgent – links the community to input from the outside world. It handles all incoming messages from the operator and passes them to the Supervisor. These messages are input through a web plug-in.

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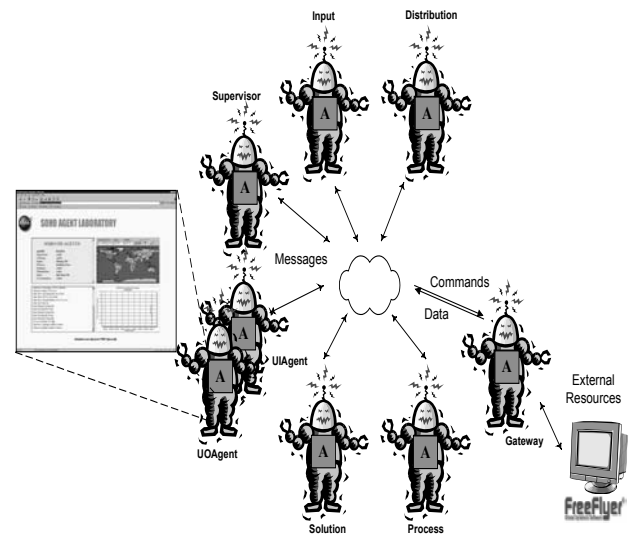
Figure 1. The SOHO Orbit Determination Agent Community

2. Implementation

The agents in the OD Agent Community were developed using the JADE (Java-based Agent Development Environment) language. This language is based on and is compliant with the FIPA ACL. Specifications.   JADE allows for great flexibility in the implementation process and was relatively easy to use in realizing the SOHO OD Agent Community. See reference [2] for technical information on JADE.

3. Conclusions

The success in developing and deploying this SOHO OD Agent Community demonstrated that a community of fine-grained agents could support the automation of a complex ground operations function. Expansion to a complete family of communities could significantly raise the level of ground system autonomy in the near future.

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References

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