UML Class Diagrams of PRISM Multi-Agent Messaging Subsystem Using XML an FIPA

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Abstract

Hurricanes, tornados, thunderstorms, and other natural disasters can have many devastating outcomes. Global warming, the prime investigated natural disaster of the PRISM (Polar Radar for Ice Sheet Measurements) project, has a tremendous effect on the sea level rise. Scientists and researchers have theorized that the excess water is being allocated from the polar ice sheets of Greenland and Antarctica due to the long-term effects of global warming; however, there are few resources to confirm the gain or loss ice.

Scientists and researchers of the PRISM project have applied their expertise on teams based on the areas of robotics, communications, intelligent systems, and radar. These areas were essential in measuring the ice thickness and determining the bedrock below the ice sheets in Greenland and Antarctica. In this research, the investigator worked with the Intelligent Systems team by learning the messaging patterns between the data producing agents and the requesting agents. The investigator also created Unified Modeling Language (UML) class diagrams of a messaging subsystem to represent the collaboration and communication between these two types of agents using eXtensible Markup Language (XML) with the Foundations for Intelligent Physical Agents (FIPA) standard codes. The class diagrams assisted scientists and researchers in planning new features for the multi-agent system.

Introduction

Global warming, the increase temperature of the earth's atmosphere, began at least 18,000 years ago when the earth started to warm it's way out of many ice ages. Scientists and researchers have noticed the increase rise in sea level over the past century. The rise in sea level is a result in the addition of water to the oceans through either the melting of or the "calving" off of icebergs from the world's land ice. Many individual glaciers and ice caps are known to have been retreating, contributing to the rising sea level. It is uncertain, however, whether the world's two major ice sheets Greenland, which has a surface area of 1.8 x 10^6 km^2, and Antarctica have been evaporating. This theory is of particular importance because of the size of these ice sheets, with their ability for changing the sea level. Together, Greenland and Antarctica contain about 75% of the world's fresh water, enough to raise the sea level by over 75 meters, if all the ice were returned to the oceans. These effects could be horrendous since 60% of the world population lives in coastal regions. In addition to increasing the amount of melting, global warming would also be expected to increase the amount of precipitation in the polar regions.

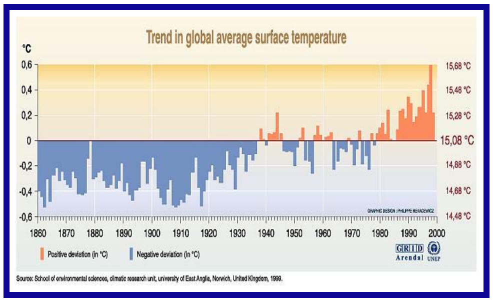

Figure 1
The chart represents the temperature trend of global warming from 1860 to 2000.

Goals of PRISM

The PRISM project aimed to design and develop intelligent radar sensors and an autonomous robotic rover for the polar ice sheet measurements of Greenland and Antarctica. The primary sensors consisted of a Synthetic Aperture Radar (SAR), which operated in either monostatic or biostatic mode, and a wideband, duel-mode radar. The SAR generated two-dimensional reflectivity maps of the bedrock. Information from the SAR determined basal conditions as well as the presence and distribution of basal water. The wideband, duel-mode radar measured the ice thickness and mapped the internal lays in both shallow and deep ice. Information from the wideband, duel-mode radar estimated the average, annual ice accumulation rate.

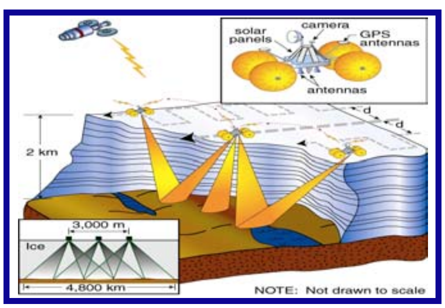

Figure 2
The SAR operated in either biostatic or monostatic operating mode in order to achieve the goals of measuring the ice sheets in Greenland and Antarctica.

Intelligent Systems

The objective of the intelligent systems team was to develop a near real-time onboard intelligent radar and rover controlling architecture that is capable of dynamically selecting the "optimum" configurations for the PRISM radar sensors and autonomous robotic rover. This includes determination of the appropriate operating (biostatic or monostatic) and frequency modes (60, 150, 550 MHz) for the SAR and the appropriate speed and scan path for the autonomous robotic rover.

The intelligent systems team used multiple collaborative agents for collection and analysis of the near real-time data sources. The information obtained from the radar onboard intelligent system was routed to a storage device on the current (Greenland or Antarctica) base station camp.

Figure 3
The intelligent system is being prototyped at The University of Kansas.

Introduction to Multi-Agent System

What is an agent? An agent is a special type of computer program that is imbued with certain abilities and responsibilities. When a group of these agents are run, they cooperate, coordinate, and negotiate in order to accomplish a common goal. The PRISM multi-agent system was composed of software agents that cooperated with each other to fulfill a large-scale goal. Each agent in the system provided capabilities and services that other agents could use.

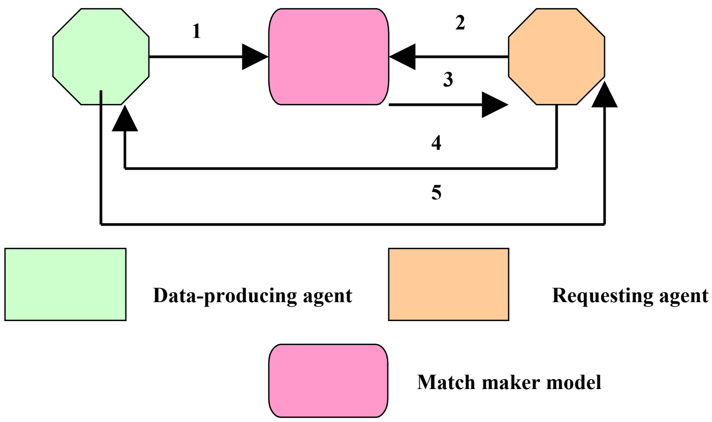

Figure 4
1. The data-producing agent registers its capabilities.
2. The requesting agent (decision maker) posts its needs.
3. The matchmaker model notifies the requesting agent that an agent can respond to request.
4. Once a match has been made, the requesting agent (decision maker) is allowed to communicate directly to the data-producing agent.
5. The data-producing agent provides the information.

Agent Messaging

The intelligent systems team has developed and tested the intelligent systems based on the matchmaker model. Under this model, agents were allowed to communicate with each other and with other information sources, such as the Geographic Positioning System (GPS), the wideband, dual-mode radar, and the SAR. The information sources appeared to the other agents in the computing environment as data-producing agents. The data-producing agents registered with the matchmaker model and advertised their capabilities. The requesting agents also registered with the matchmaker model to post their needs. The requesting agents determined the decisions for the intelligent radar and autonomous robotic rover. Once the matchmaker model has paired agents with the corresponding requests, the data-producing agents communicated directly with the requesting agents instead of the matchmaker model. The intelligent systems team has also implemented a protocol where requesting agents register data requests with data-producing agents. The requests were time - or event – based. Time-based monitoring required data-producing agents to send information to the requesting agents at specified time intervals. Event-based monitoring required data sources sent to the requesting agents when a specific event occurred.

Agents in the multi-agent architecture communicated with each other by XML messages that conform to FIPA Communicative Act, FIPA Agent Communication Language (ACL), and Resource Description Framework (RDF) standards. The PRISM multi-agent architecture supports many of the standard performatives defined in the FIPA Communicative Acts. FIPA ACL defines the message structure among agents. The content expressed in the multi-agent system conforms to FIPA RDF.

XML Code

```
<?xml version="1.0" encoding="UTF-
8"?>
<fipa-message act="inform">
   <sender>
            <agent-identifier>
         <name id="TEMPERATURE-
AGENT"/>
<user-defined>[TEMPERATURE-
AGENT,3]</user-defined>
            </agent-identifier>
         </sender>
         <receiver>
            <agent-identifier>
               <name id="ROVER-
DECISION-AGENT"/>
               <user-defined>[ROVER-
DECISION-AGENT,27]</user-defined>
            </agent-identifier>
```

```
          </receiver>
          <content>
             <rdf:Description
about="temperature_suba_0">
          <fipa:done>true</fipa:done>

          <fipa:result>19.984596</fipa:res
ult>
             </rdf:Description>
          </content>
          <language>PRISM:FIPA-
RDF</language>
          <in-reply-to>temperature-
request-1</in-reply-to>
</fipa-message>
```

Figure 5
An example of the messaging code among agents is guided by the Inform Message. In this example, the temperature agent, the sender and a data-producing agent, is communicating with the requesting agent (rover decision agent), the receiver. The rover decision agent is requesting information about the temperature from the temperature agent. The agents communicate between each other using XML that conforms to FIPA ACL and RDF. Java allows the message to be generated from one agent to another, and it distributes the message.

Introduction to Unified Modeling Language (UML)

UML is an object-oriented system of notation created by Grady Booch, James Rumbaugh, and Ivar Jacobson. It is used for visualizing and constructing the elements in a software based system. There are 10 different UML models.

Class Diagrams

A class diagram consists of a group of classes and interfaces reflecting important entities of the system being modeled, and the relationships between the classes and interfaces. Classes and interfaces in a class diagram are interconnected in a hierarchical fashion.

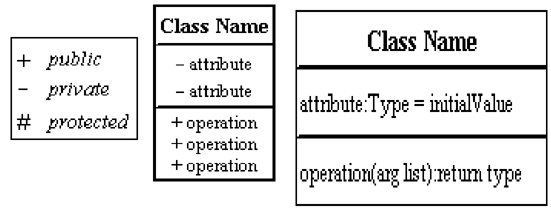

Figure 6
Classes in a class diagram are represented as rectangles divided into three compartments. The first compartment contains the name of the class, the second compartment contains the attributes with return data type, if any, and the third compartment contains operations/methods with return type, if any. On the left of the attributes and operations is visibility. Visibility determines how classes obtain access to the attributes and operations. Attributes and operations are private, public or protected if a subtraction sign (-) , addition sign (+), and pound sign (#) appear, respectively.

Description Message

The investigator on the PRISM project implemented UML class diagrams of the messaging patterns among agents. The UML Description Message is an excerpt of the messaging patterns defined by a class diagram.

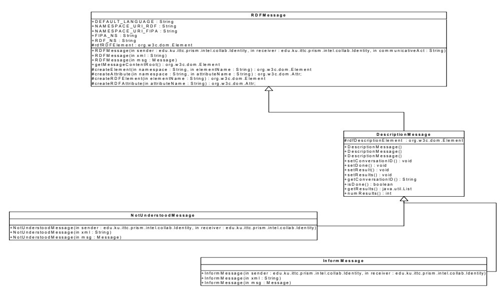

Figure 7
In this particular example, the Description Message is shown with its children Not Understood Message and Inform Message. The Not Understood Message and Inform Message are two types of Description Messages. The Description Message is considered the content because its attribute is standard for FIPA RDF. This example shows a typical communication act among agents. If an agent requests information from another agent, and if that agent does what the agent wants in regards to the information, that agent will go through a similar process as described in Figure 5. If the agent does not correspond to what that agent says, the message is Not Understood. When a message is not understood, the data-producing agents cannot subscribe information.

Conclusion

The PRISM project is a five-year project with a motive to measure the ice thickness. Each year there are modifications to make the project simpler than the past year. PRISM scientists and researchers have designed advanced radar sensors to study key aspects of glaciology, built a novel mobile robot with the capacity to carry the intelligent radar sensors. The investigator for the Intelligent Systems subdivision of PRISM allowed scientists and researchers to make modifications to the multi-agent system. The modifications included reconstruction of agents so that the corresponded information would correspond to the correct agent.

Acknowledgements

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