

Georgia Institute of Technology

RTI selected for Unmanned Helicopter

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Aaron Kahn
Chief designer of the
Georgia Tech helicopter

The schedule is ambitious. The deadlines can't be missed. Not a line of code has been written. There's no time for prototyping. There aren't enough developers to do the work.

Sound familiar? Engineers at Georgia Institute of Technology's Unmanned Aerial Vehicle Research Facility (UAVRF) were recently faced with just such a situation.

They were developing a small, autonomous, radio-controlled helicopter to fly in the International Aerial Robotics Competition (IARC) and they had only a short time to put it all together. One of the critical components was the software that their unmanned helicopter would use for communications with their ground station.

The communications software had to be small, simple, intuitive to use, and available off the shelf. They found what they were looking for in RTI Data Distribution Service (formerly NDDS). RTI eliminated time-consuming and complex network programming. Using RTI, the Georgia Tech team was able to get its helicopter flying under complete computer control in time for the competition.

The Ultimate Collegiate Challenge

The IARC is sponsored by the Association for Unmanned Vehicle Systems (AUVS) International. It captures the competitive spirit of graduate engineering students from many of the top universities around the world. The AUVS sponsors annual autonomous robotics competitions in aerial, ground, and undersea categories. These competitions require undergraduate and graduate students to design and build unmanned vehicles that attempt to complete a predefined mission. The AUVS competitions are billed as “The Ultimate Collegiate Challenge.”

An IARC mission is often very complex. For example, this past year's competition required the unmanned aerial vehicles



Figure 1. A Hazard From The International Aerial Robotics Competition

(UAVs) to complete a search-and-rescue mission over a five-acre area that simulated an urban natural disaster. This simulated disaster area included hazards such as natural gas leaks and broken water mains—where actual flames and waterspouts were shooting into the air. (See Figure 1). For the mission, the UAV was required to locate simulated survivors of the disaster and identify various hazardous materials strewn throughout the area.

The Georgia Tech Entry

Preparation for such a mission can take years. The problem for the graduate students at the Georgia Tech UAVRF was that they did not have years; they had only five months to put together a working helicopter from scratch. They had to select the hardware components, build the helicopter, write and test the software, and fine-tune the flight controls. Even though autonomous aerial flight was not new to the Georgia Tech team, the task was still daunting.

First, the team selected the various hardware components. In addition to normal helicopter equipment, the UAV was equipped with a small circuit board containing an AMD 486DX5-133 processor, 128 MB of RAM, and 64 MB of flash memory. It also was given a Global Positioning System, a SONAR altimeter, and an Attitude and Heading Reference System.

Communications between the helicopter and the ground station were provided over wireless Ethernet. While some members of the team worked on integrating the various hardware components, others selected the software components used on the project. RT-Linux was chosen as the operating system for the embedded processor on the helicopter, and Red Hat Linux was selected as the operating system for the ground station computer. To minimize software development time, the team knew that they needed to use as many off-the-shelf software components as possible. “We found that a good mix of the right software tools and middleware cut development time and minimized confusion,” said Aaron Kahn, chief designer of the Georgia Tech helicopter.

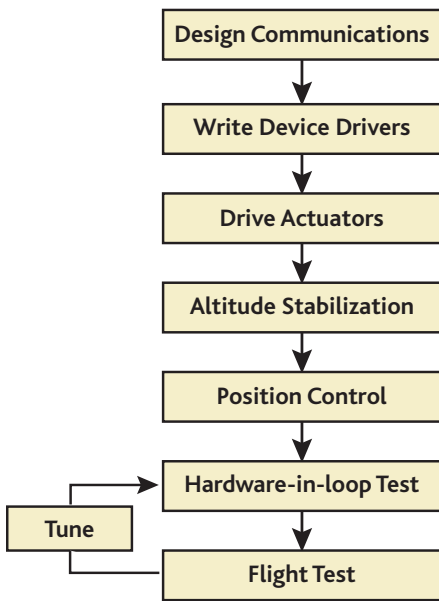


Figure 2. The Software Development Process

The first step of the software development process was to design a communications subsystem. (See Figure 2.) This would ensure that all the various software systems could communicate in an easy, scalable, and flexible way—regardless of whether the systems were local or remote (that is, across the wireless network). The team decided to use off-the-shelf communications middleware to save both time and resources. “Using off-the-shelf middleware helped us to focus more completely on our overall objective rather than on the details of message-passing algorithms or network programming idiosyncrasies,” said Kahn.

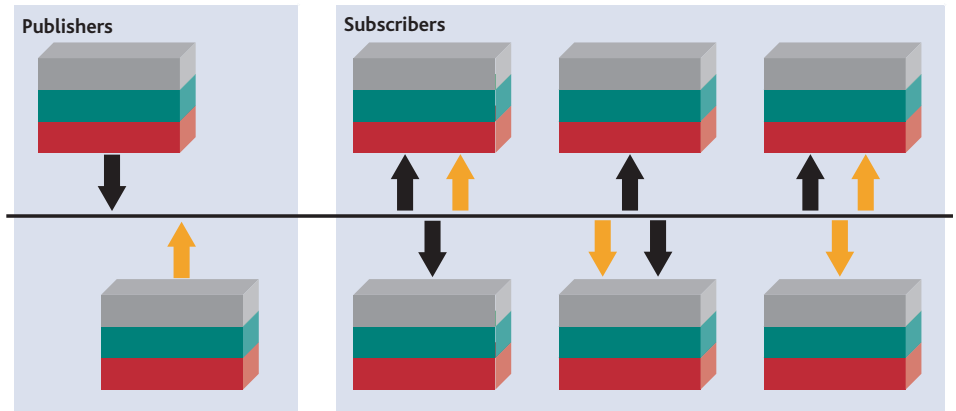


Figure 3. Publish-Subscribe Middleware

RTI: Off the Shelf and Into the Air

Several off-the-shelf options for middleware were considered. “We looked at CORBA, but not only was it too large for our embedded application,” said Suresh Kannan, chief software architect for the project, “but the ramp-up time to use it was prohibitive. Just to send a few data values from one system to another required too many rules, conventions, and standards for us to figure it out expediently.” In contrast, RTI Data Distribution Service—the real-time, publish-subscribe middleware that was selected—required virtually no ramp-up time. “What is really impressive about RTI is that it is extremely robust, yet both simple to use and very fast.”

The publish-subscribe model for messaging is shown in Figure 3. Nodes that produce information (publishers) create “topics” (such as temperature, location, or pressure) and publish “issues” of that topic. The issues are then delivered to all subscribers that have declared an interest in the topic. The middleware handles all the transfer chores: message addressing, data marshaling and demarshaling (so subscribers can be on different platforms than the publisher), delivery, and flow control.

For example, in the case of the Georgia Tech helicopter, differential corrections were labeled with the topic `gs.diff` and published to the middleware. Any other system, either local or on the network, simply subscribed to the `gs.diff` topic and received new issues automatically as they were

Publish-subscribe middleware simplifies many-to-many communications. Publishers just declare a publication, define the topic and give the issues to the middleware. Subscribers just declare interest in a topic. The middleware takes care of all the network addressing and sends the issues only to the nodes that declared an interest.

published. Both intertask communication and ground-station-to-helicopter telemetry systems utilized RTI middleware.

Once the team established messaging between software subsystems, it “never had to bother with it again.” It saved the project weeks, or perhaps even months, of development time. “Without RTI, I know that we would have spent a lot of our time trying to hack together some type of communications code which may not have ever worked,” said Kahn. “Without RTI, our goal could never have been accomplished.”

Although a lot of data was sent to and from the aircraft over the wireless network, RTI overhead was never a concern. In fact, RTI overhead remained negligible while handling data at a rate that, in one test, neared the physical limits of the wireless hardware.



Figure 4. Georgia Institute of Technology Helicopter at International Aerial Robotics Competition

Conclusion

By utilizing off-the-shelf publish-subscribe middleware, the Georgia Tech team was able to meet a very aggressive software development schedule. There was still plenty of work to be done when the team arrived at the 2000 International Aerial Robotics Competition, but debugging communications software was not a part of it. As might be expected, a number of aircraft in the competition crashed during the test flights that preceded the final competition. However, the Georgia Tech UAV was one of only two crafts to fly completely under computer control and make it through to the final stage of the competition. As a result of this success, the Georgia Tech UAV Research Facility is using RTI Data Distribution Service on new research projects—and, of course, any future aerial robotics competitions.

About RTI

RTI supplies middleware and distributed data management solutions for real-time systems. With innovative technology and deep expertise in distributed applications, RTI provides an unequalled competitive advantage to customers developing systems that benefit from high-performance access to time-critical data. RTI solutions have been deployed in a broad range of applications including command and control, intelligence, surveillance, data fusion, simulation, industrial control, air traffic control, railway management, roadway traffic monitoring and multimedia communications. Founded in 1991, RTI is privately held and headquartered in Sunnyvale, California.