Optimizing Satellite Communications

Using artificial intelligence to aid satellite communication managment

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Stottler Henke
Smarter Software Solutions

Imagine you're a commander faced with an attack on our satellites and ground communication facilities. How can you best reshuffle the satellite communications schedule to compensate? What will be the impact to ongoing missions? Which facilities need to have the highest priority to be defended? The answers are critically important and require high-level reasoning skills to develop solutions adequately balancing every concern. But what if at least part of this reasoning process were automated?

THE CHALLENGE

Satellite schedulers working for the Air Force Satellite Control Network (AFSCN) are responsible for scheduling hundreds of millions of dollars' worth of ground satellite equipment, squeezing out the highest communication capability possible while protecting the billions of dollars' worth of on-orbit satellites that are crucial for our nation's defense. When a vehicle emergency is declared for even one of these satellites, schedulers must quickly reshuffle the communications plan to maximally support both the distressed vehicle and the high priority tactical missions it supports. Balancing these priorities effectively is known in the industry as "deconfliction." Before the Managed Intelligent Deconfliction and Scheduling (MIDAS) system, deconfliction could only be as fast and as good as the expert humans working at AFSCN. Now, satellite schedules are more effective than ever.

I can't imagine scheduling without the MIDAS automation system. It's a no brainer. To me, the fact that MIDAS can auto de-conflict a 24 hour schedule in less than five minutes is amazing.

WHY IT MATTERS

The Air Force needed an automatic, intelligent software system that could quickly schedule and deconflict the communications requests from separate satellite operations centers (SOCs). Without MIDAS, the scheduling and deconfliction process requires excessive manpower from highly trained and highly skilled operators, each requiring almost a full year of training with a high washout rate. There was no way to quickly assess the impact of outages, vehicle emergencies, attacks, or possible changes to the communications systems. These very difficult, complex, and challenging problems inherently lead to inconsistencies in the schedules previously produced. Currently, the approximately 600 scheduling requests per day from dozens of SOCs must be manually scheduled and deconflicted by three expert schedulers during an 8 hour shift. The number of supported satellites and accompanying communications requests is growing, while the resources to support them remain flat, leading to an ever-increasing number of difficult-to-resolve conflicts requiring human adjudication. The existing process makes quick assessments and changes impossible.

THE SOLUTION

After ten previous failures at trying to automate these human decision-making processes at a cost of tens of millions of dollars, Stottler Henke was selected to make an eleventh attempt at this important problem. Our work in Artificial Intelligence (AI) is aimed at mimicking human thought processes to solve useful problems. Human schedulers existed as a proof by example, demonstrating that a solution was possible every day that they solved deconfliction problems. Our solution was to study their cognitive processes and determine how to replicate them in software.

> ***MIDAS provides leadership with rapid AFSCN assessments as outages negatively impact the network, shaping how operational capability is restored under normal and extremely stressful situations.***
>
> ***Brian Bayless***
>
> AFSCN Integrator, 22nd Space Operations Squadron at Air Force

HOW IT WORKS

Scheduling and deconfliction occurs primarily in two steps. When change requests arrive (around 600 each day) typically half of them are in conflict. The first step is for MIDAS to deconflict as many of these as possible, while obeying all of the constraints in the request. For example, some requests may have some leeway as to the exact time or ground antenna to use. Automatically re-shuffling schedules while obeying all the given constraints tends to solve about half of the conflicts. Solving the other half requires applying empirical knowledge to "bend the rules". Experienced schedulers know how requests can be violated in small but acceptable ways, depending on the specific satellite involved. MIDAS uses this knowledge, encoded as user-editable business rules, to iteratively focus on and solve each remaining conflict. This may involve shaving off ground station preparation time, switching antenna sites, handing off a long support in the middle to another site, using alternative equipment, not having requested redundant equipment available, etc. A solution to one conflict may involve several different business rules at once (e.g. switching sites and shaving time from two requests) or may involve a "domino" process, where one conflict is solved at the expense of creating another, which is, itself, solved in turn. On a daily basis, MIDAS saves man-hours, allowing schedulers to focus on higher level concerns.

IMPACT FOR THE FUTURE

Recently, budget hawks made a compelling cost-saving case for shutting down two sites. To justify keeping them open, MIDAS was used to quickly schedule the previous month's worth of requests and show the severe mission impacts that would result from these closures. During real or training emergencies, MIDAS allows much quicker impact determination and new optimized schedule creation.

MIDAS has been an impressive application demonstrating how we can replicate human thought processes in a very difficult domain. This has allowed us to win more work for direct follow-on projects, additional projects in the space field, and other intelligent scheduling projects. Project wins include missile defense scheduling and sensor data fusion, space surveillance scheduling, SOC automation and others. We have acquired additional contacts in the space field including at the NRO, MDA, etc.

Many of the intelligent scheduling algorithms developed as part of the MIDAS effort have been incorporated into our commercially available Aurora intelligent scheduling tool which is sold to and used by many American manufacturing companies including Boeing and Learjet. Aurora is also used at NASA KSC to make scheduling and processing of space vehicles more efficient as well as by training hospitals, dental schools, and for airline pilot training.

Part of the MIDAS development process consisted of many frequent iterations of the MIDAS software with the expert schedulers. By critiquing its results, literally hundreds of undocumented requirements for an automated scheduling and deconfliction system were discovered, recorded, and implemented in software.

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The MIDAS Touch

Our military has come to rely heavily on expensive, space-based assets. Protecting these assets requires frequent communications necessitating the use of limited, expensive ground assets. Optimizing the communications schedule maximizes use of expensive ground resources, making a difference in costs related to observation and management, while also providing efficient re-planning for events of weather or other outages.

GALLERY

Onizuka AFS, Air Force Satellite Control Network

Remote Tracking Station

Thule Tracking Station, Greenland

Stottler Henke Associates, Inc.

www.shai.com

1670 S. Amphlett Blvd., Suite 310, San Mateo, CA

Stottler Henke, founded in 1988, is an Artificial Intelligence R&D firm of about 40 people from top AI universities which creates and applies artificial intelligence and other advanced software technologies to solve problems that defy solution using traditional approaches.

Dick Stottler

Co-Founder, President, CEO, and Project Manager

Kyle Mahan

Project Software Architect

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