Success Story

Air Force Research Laboratories

Satellite-based radar systems acquire terabytes of information daily, presenting a formidable challenge for algorithm development and processing.

SGI at AFRL

Scalable Processing Power for Satellite Radar Imaging

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– Mark Barnell, Onsite Systems Engineer for AFRL

The United States Air Force has relied on radar images for decades. The recent introduction of satellite radar data literally inundated the existing imaging systems, and created the need to efficiently process terabytes of data. SGI and Interactive Supercomputing (ISC) partnered with the engineers at the Air Force Research Laboratories (AFRL) to give the radar imaging team a more powerful processing platform, protect years of investments in custom imaging software, and improve the overall workflow within this highly collaborative research community.

New Technologies for Accelerating an Old Technology

Radar—the use of radio waves to detect the presence of metal objects—has been around since approximately 1904. AFRL drives this technology forward by researching and applying new enablers and innovations including a variety of image processing techniques. At the AFRL Rome Research Site (RRS), the radar researchers recently set out to overcome computing restrictions that were inhibiting the advancement of research into imaging algorithms. Compute-intensive processing requirements, the lack of high-level interactive tools, and the massive quantity of satellite data combined to restrict the team to a cumbersome batch processing workflow.

"Most of the algorithm research is done on PCs," explained Mark, the onsite systems engineer for AFRL. "Years of work are tied to MATLAB and the researchers needed a way to speed up processing without having to rework the huge investment in existing software. The group had access to a variety of high-performance computing platforms, but the problem was one of migrating existing MATLAB code to these platforms. We also needed a large amount of memory—a requirement that made it difficult to split the software for migration to a cluster. We knew that the SGI® Altix® system, with its parallel processing capabilities and large shared memory architecture, was the ideal target,

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but we couldn't easily get there. At the same time, the rapid changes in the threats our war-fighters are encountering means that we have to be able to respond rapidly with new algorithms capable of using state-of-the-art HPC systems."

Pain-free Parallelization

Simultaneously, a combination of technologies and partners was coming together to offer a possible solution for the AFRL team. SGI and Interactive Supercomputing (ISC) co-developed a MATLAB-compatible environment on SGI Altix systems.

The SGI-ISC relationship gave the AFRL team an opportunity to participate in the final stages of development for the new ISC Star-P interactive parallel computing platform. Star-P enables the parallelization of desktop codes, models, and algorithms. Using Star-P, code can transparently take advantage of high-performance computing platforms and provide teams with interactive execution response. Originally developed at MIT on a Linux cluster, Star-P was commercialized by ISC and SGI on the SGI Altix platform. The AFRL team provided a perfect test case for the new solution.

"Star-P opens up the world of high-performance computing to teams that have outgrown their current desktop platforms," explained Steve Reinhardt, Chief Engineer at SGI, and a contributor to the joint AFRL-SGI-ISC project. "The SGI Altix platform brings limitless scaling potential to teams like the researchers at AFRL. With trivial changes to their code, the team went from a 12 – 24-hour iterative cycle to a cycle that could be carried out in several minutes. This has not only changed the way they work today, but it has given them the ability to tackle problems that they couldn't imagine solving in the past."

The Star-P environment supports existing MATLAB code using the same very-high-level language constructs. Users are shielded from the complexities of parallel computing, but can benefit from features such as large memory, 64-bit addressing, and parallel I/O to large data stores.

Unimagined Scalability

While Star-P has smoothed the road to high-performance computing, the SGI Altix platform has proven to be particularly well suited to the AFRL team. The strong interconnection network of the Altix system provides efficient interprocess communications compared to more overhead-intensive cluster environments. In the case of Star-P, this has translated into optimized scalability. Within the Air Force research community, the AFRL team has access to multiple SGI Altix platforms. Local systems include an eight-processor SGI Altix 3300 with 28GB of memory. The team can also take advantage of a 256-processor system, and a high-speed (OC-48) network gives them access to other Air Force high-performance computing assets including an SGI Altix Eagle system with 2048 processors and 2TB of RAM.

For the ongoing work at AFRL, the combination of Star-P and the SGI Altix platforms has virtually turned desktop

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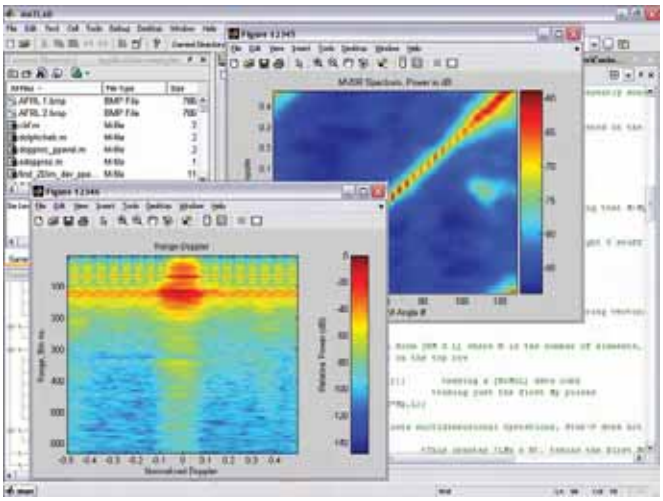
systems into supercomputers. Project team engineers can sit at their desks and work in the same way as in the past, but now with transparent access to all of the community's computing resources. So far, they have seen incredibly scalable results.

For example, processing one 200x200 pixel image used to require 4800 seconds on a PC. AFRL changed from a looped algorithm to a row algorithm and doubled the speed, but it still took 40 minutes to process a single image. With access to an 8-processor 28GB Altix system, processing time for the same image drops to about 15 minutes. "The 256-processor, 2TB system drops the processing time to less than 3 minutes and enables AFRL to solve the large problems they really need to solve," said Barnell. "We never imagined being able to achieve this magnitude of scalability with the existing software. The potential is phenomenal, considering the other compute resources that the team now has available from their desktops."

Versatile Computational Options

The move to the SGI Altix platform also gives the team access to a diverse set of commercially available compute technologies. For example, field-programmable gate arrays (FPGAs) give the AFRL team an important resource for the acceleration of algorithms. The ability to incorporate FPGAs into the Altix computing environment enables transparent access to more compute power or extreme data-ingest speeds from the same familiar MATLAB environment. Unlike clusters, the Altix architecture is designed to provide common resources (e.g., memory, FPGAs) across all processors.



Researchers at Air Force Research Lab use MATLAB to evaluate radar analysis algorithms, and wanted to preserve the familiarity and interactivity of their desktop environment while taking advantage of the computational power of parallel systems.
(courtesy Mark Barnell, Air Force Research Lab, Rome, NY)

If It's Not Broken, Don't Fix It—Just Port It

MATLAB has served as a familiar and effective environment for imaging research associated with past radar systems and now the new tomography approaches that take radar into the world of 3D imaging. "AFRL is typical of many very large, collaborative community of researchers," said Reinhardt. "It would be inconceivable to move the whole community and the massive amount of research into high-performance computing environments if we had to convert them to a new programming religion. With Star-P on the SGI Altix platform, we can let them keep everything they like about their existing computing environments, and simultaneously give them a pain-free way to explore new approaches. It's these new approaches that will let them solve problems that have held them back in the past. It's not exaggerating to say that we expect AFRL to make major breakthroughs as a result of the SGI-ISC solution."

Today, the AFRL team has gained increases in processing throughput, and the ability to tackle much larger images and data sets without breaking the problem into smaller subsets. Without having to change their software foundations, the move to high-performance computing introduces a level of interactivity that has already fostered new thinking and innovative approaches for problem solving.

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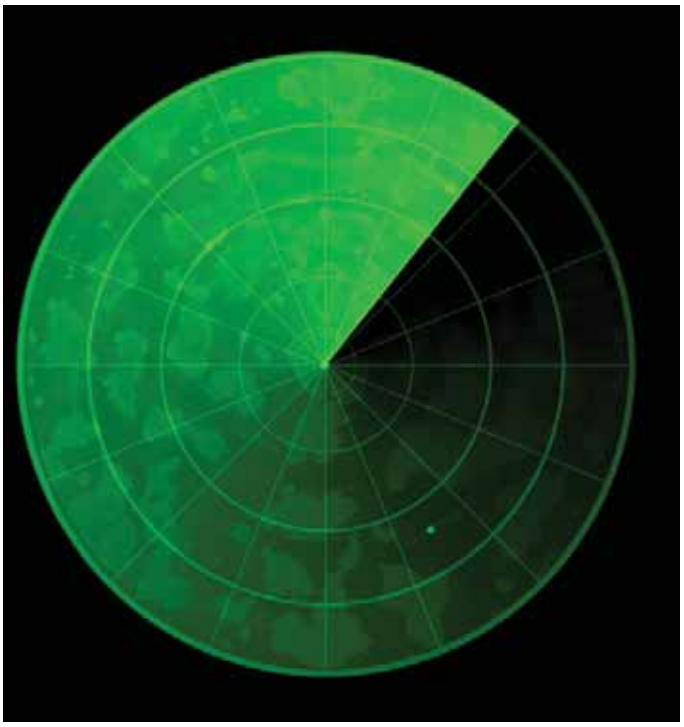

The modeling and simulation efforts within Air Force Research Lab have become increasingly complex, and an interactive MATLAB environment is used to develop, test, and analyze surveillance assets.

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