Computers in engineering

Visualizing the future of aerospace

In the world's largest building, there's plenty of room for new ideas. At 472-million ft^3 by volume, **Boeing**'s sprawling factory in Everett, WA, has long been home to innovative thinking. Boeing engineers constantly evaluate technology solutions that could benefit the company's operations. At a supercomputing conference in late 2005, a demonstration in Seattle brought Boeing together with **SGI** and **Intel** to show how the Everett factory might further streamline in-factory quality assurance processes.

The demonstration offered a real-world scenario: A Boeing Quality Assurance analyst on the factory floor, equipped with a portable computing device, compared finished Boeing 777 aircraft parts and assemblies with the original design to check for variances. Using a Visual Area Network and video-conferencing technology, the Quality Assurance analyst remotely conferred with a Boeing Liaison Engineer, who interactively viewed the same model to validate any potential workarounds. Unlike real-life factory scenarios, where analysts and engineers must walk from place to place to assess problems and authorize changes, the interactions between the demonstration analysts and engineers occurred remotely, collaboratively, and in real time, thanks to the ability of all parties to view the same Boeing 777 design, no matter where they were located.

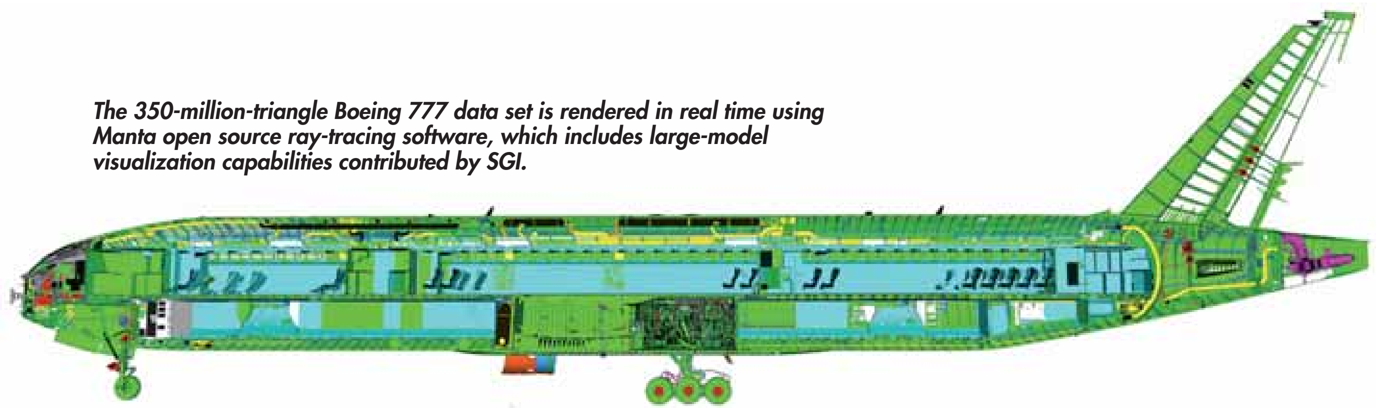
At the heart of the demonstration was an interactive display of the entire original CAD model of the first Boeing 777 aircraft, a massive data set made up of 350 million polygons representing 16,000 different models—14 GB of data. To render the huge model on demand, the demonstration team relied on a technique called real-time ray tracing.

Ray tracing is a rendering technique that uses the behavior of light to generate extremely realistic, detailed images. The ray-tracing algorithm projects a ray through every pixel on the screen and traces it to the 3-D scene image. The algorithm then calculates how the ray and the light source intersect with the objects in the scene. Ray-traced renderings present real-world 3-D volume data with photo-realistic accuracy. Engine makers, for instance, could use real-time ray tracing to visualize in 3-D detailed scans of engine heads and aluminum castings as they check for fissures or other microscopic defects.

Ray tracing was invented in the early 1960s to simulate the effects of nuclear penetration, but until the past few years its use was limited. Because ray tracing performance scales with the number of processors available to it, the widespread adoption of costly graphics processing units (GPUs) in the 1980s and 1990s convinced many that, for all its advantages, ray tracing was too computationally expensive for mainstream use. Strictly GPU-based ray tracing would require too many expensive processors to make the technique affordable even for most high-performance computing (HPC) budgets.

But with the advent of scalable, 64-bit processors capable of leveraging large shared-memory computer architectures, ray tracing has become a cost-effective, real-time rendering option. As a result, real-time ray tracing has been embraced in HPC environments as varied as manufacturing, oil and gas exploration, and medical research.

These users have found that ray-tracing solutions can scale on a sub-linear curve as a rendered scene grows more complicated, and can scale from two processors to hundreds. This means that real-time ray tracing vastly exceeds what can be rendered on today's typical desktop system.



The 350-million-triangle Boeing 777 data set is rendered in real time using Manta open source ray-tracing software, which includes large-model visualization capabilities contributed by SGI.

Another advantage of real-time ray tracing is that it can leverage HPC resources already in place at many of today's leading aerospace engineering companies. In particular, ray-tracing software excels on shared-memory systems designed to hold entire data sets in memory for maximum access and interactivity. Shared-memory systems offer an enormous advantage over 32-bit commodity **Linux** clusters. Although an organization might have a 200-node Linux cluster in place, to ray-tracing software these cluster nodes may as well be separate systems, which leads to latencies that make attempts to interact with large data sets completely unsatisfactory.

In contrast, 64-bit shared-memory Linux systems, such as the SGI Altix family, offer standards-based architectures that can scale from two to hundreds of processors in a single node. In fact, the combination of commercial and open-source ray-tracing software, 64-bit processors, and powerful shared-memory servers have created an environment for cost-effective, massively scalable real-time ray tracing.

For organizations struggling to visualize ever-larger models and real-world 3-D volume data, this may well be an innovation whose time has come.

This article was written for *Aerospace Engineering* by **Himanshu Misra**, Business Manager, Manufacturing Industries, SGI.

New supercomputers at NASA Goddard

As part of a contract with the **NASA** Center for Computational Sciences (NCCS), **Computer Sciences** Corp. (CSC) has ordered a custom supersystem from **Linux Networx** for installation at the **Goddard Space Flight Center**. The system, designated for installation in mid-June, was designed to increase throughput for applications ranging from studying climate and weather to simulating astrophysical phenomena.

The 128-node, 3.3 trillion floating-point operations per second (TFLOPS) supersystem is the cornerstone of an expandable cluster environment. In its full configuration, the system is designed to be scaled to as many as 40 TFLOPS.

"It was put together in such a way that you could acquire scalable units of about 128 to 256 nodes a piece," said Linux Account Manager George Herning. "And the switch fabric is already there so it allows you to do almost an expansion into an existing fabric without having to go back and do a completely new system.

"We could see expansion at least up to another four or five of these scalable units before space, heat, or size considerations start to come into play."

Features of the system include **Intel** dual-core Dempsey processors and an Infiniband Network from **Silverstorm Technologies**. For added performance, a high-performance storage subsystem was included with 60 TB of raw **Data Direct Networks** (DDN) storage running the **IBM** General Parallel File System.

Linux was chosen over IBM and **Dell** to provide the system and attributes part of its selection to its ability to work within a partnership.

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"When it came to who could do the job for the folks at NASA, we were able to assemble a pretty strong group of partners to both work with us financially and technically to be able to generate this kind of system," said Herning, citing Linux's relationship with Intel, Silverstorm, and DDN.

Linux also met NCCS's price/performance needs and was chosen for its system reliability and the ability to incorporate new technologies over time.

"The technology flexibility offered in our program appealed to the NASA and CSC folks very much so regarding our CPU flexibility and our file system flexibility," said Herning.

This is Linux's second major order by a government agency in the last four months. In February, the U.S. **Department of Defense** ordered five Linux cluster supercomputers, the largest single order for supercomputers in the company's history. The $17.2 million order was part of the DOD modernization program at the Army Research Lab in Maryland.

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