Success Story

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SGI and TotalFinaElf

Successful Exploration for Oil by Visualizing the Past and Future

Positioned for Success

TotalFinaElf, the major French oil and gas company, is reorganizing its scientific computing system by relying on the expertise and technical support of SGI. TotalFinaElf is seeking to improve data access, increase computing power, and facilitate interpretation of geoscience data to increase production and better manage oil fields.

It may seem strange, but these days an oil discovery may be thought of as a computer product. It's a fact that exploration prospects are not developed in the field as a result of locating the telltale surface signs of the precious fluid. Instead, exploration now takes place on displays in computer rooms and uses the most advanced technology to efficiently process the tremendous volume of data derived from exploration campaigns. In this context, the role of TotalFinaElf's Expert Center in Pau, south of France, is to develop and maintain the technical knowledge needed by 44 exploration and production subsidiaries to identify the least risky onshore and offshore exploration prospects to be drilled or to help in the development of various oil and gas fields. The more than 1,500 people working in the Expert Center have to constantly refine the methods for collecting and processing this information once it is gathered from the field to maximize production of oil in the reservoir.

TotalFinaElf Identified Three Computing Needs

Arnaud Althabegoïty, information technology support manager for the TotalFinaElf geoscience department, explains that in order to deal effectively with the increased volume and the changing nature of the data that had to be processed, TotalFinaElf needed to revamp its computer facility to achieve three goals: to provide increased computing power for data processing purposes; to make data more readily accessible; and to set up a virtual reality room to provide a collaborative and immersive environment for the exploitation of processed data.

"And there is no denying that SGI was an enormous help to us with each of these projects," says Althabegoïty.

"Our experience in the field of intensive vector calculus began over 10 years ago, and in 1997, we opted for an SGI Origin 2000 server," recalls Bernard Prim for TotalFinalElf, SGI server operations manager.

The company subsequently added two more SGI® Origin® 2000 machines, each of them functioning as a compute server for the data allocated to it. One of these machines also acted as a data server with access, via a 1.25TB SGI® DMF (Data Migration Facility) buffer, to a gigantic 34TB data warehouse made up of tapes inserted on demand into readers by a robot. These three servers were linked together by a 100Mb-per-second local FDDI network operating under NFS, which was connected to the enterprise network.

But this architecture resulted in a number of problems: The machines accessed data interdependently; the machine accessing the data warehouse was diverted from its compute server function; local storage capacity was no longer adequate for the growing volume of the surveys; and the constant exchange of data through the network resulted in a prohibitive data recovery time. A change was needed.

Increased Computing Power: Seismic Acquisition and Processing

Seismic analysis is one of the most efficient exploration sidebar techniques. It consists of creating, after a survey, a digital image of the structure of the oil prospect or field to be evaluated—and does so by analyzing the effects of sonic waves reflected back to the surface from layers of strata in the subsurface. This technique is called 2D-reflection seismology. A strong sonic wave front is created at a point on the surface, and the wave front is directed into the earth. The sonic waves are partially reflected off rock layers and travel back to recording instruments at the surface. The recording geophones are located at precise distances from the sonic source and this pattern of sourcing—called "reflecting"—and recording is repeated many times to reveal the subsurface secrets of the earth. The repetitive geometry of this multiple pattern of source and receiver locations can be summed into a single vertical

3D Geovision: A Three-Dimensional Advanced Visualization Space for Optimal Data-Interpretation Conditions

With the help of SGI® technology, the TotalFinaElf group has developed a Geovision three-dimensional advanced visualization center in Pau, which is intended primarily for collaborative work and will enable its geoscience experts to optimize data use. The highly innovative objective was to provide work groups with a versatile 3D viewing environment that could provide access to all types of software, data sets, and related interpretive material available on the local enterprise network. The key considerations in the design of this room were visual immersion, integration, and interactivity.

trace located midway between the source and receiver. Many processing steps are applied to the raw data to remove unwanted waves, exclude multiple-bounce reflections, and extract the amplitude or strength of the reflection and other characteristics of the seismic recording process. The end result is a single seismic trace that is a composite of the many offset traces recorded during the acquisition of the seismic survey. A variable curve of amplitude is then obtained from all surveys recorded over the reservoir and depends upon the amount of time elapsed between the seismic surveys. From the dozen measurements calculated on each vertical axis from the present survey to the original program that was shot a few decades ago, TotalFinaElf has now reached a total of more than 500 measurements that were recorded over an extended period of time for the subsurface reservoir in question.

But even this is not enough in today's competitive energy market. It is not the 2D structure of the earth under a straight surface line that TotalFinaElf is looking for, but a complete 3D description of the entire oil field that can range in size from a few hundred to a few thousand square kilometers. Acquiring a 3D representation of this earth model is accomplished using a grid of source and receiver patterns, exacting position recording techniques, and high-speed data recording equipment to shoot and record a 3D seismic data volume. The 3D-reflection pattern is recorded from a densely spaced grid pattern determined by the objective of the survey. The acquisition techniques commonly utilized in acquiring 3D seismic data result in a redundant collection of subsurface reflection points that are collected in a bin that usually measures 25 to 50 meters to a side. The volume of raw data gathered this way can amount to dozens of terabytes that must stored and processed in order to be usable in understanding the oil field in question. The final seismic volume may also be converted from a volume showing sonic travel time to a depth volume utilizing many hours of high-performance compute power before it is ready for final interpretation.

More Computing Power: Absorbing Peak Workloads

"Our role was to set up adequate computer means to keep the geophysicists from getting blocked in their work, despite the unpredictable nature of their workload," says Althabegoïty. "The duration of their work varies from half a day to a year, although the average is about one month. We therefore opted for a computer configuration loaded, on average, to 60% of its capacity, which leaves us a reserve to absorb peak loads. We evaluate the profitability of an oil exploration project on an overall basis and not on the basis of a single element, such as the computing element. It is therefore essential that the computing element does not inhibit the productivity and inventiveness of the experts, because they could then miss important indications."

Readily Accessible Data: SAN Empowered by SGI® CXFS®

The first step was to create a SAN (storage area network) at the end of year 2000. All data was centralized in SGI® TP9400 multiple-controller RAID 3 rack-mounted disk arrays, meaning that it became accessible from all machines without the constraints imposed by the network and the use of multiple communication protocols. Both security and throughput were enhanced, but it was still necessary to go through NFS to access data for which another machine was responsible.

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Geoscience DepartmentInformation Technology Support Manager,
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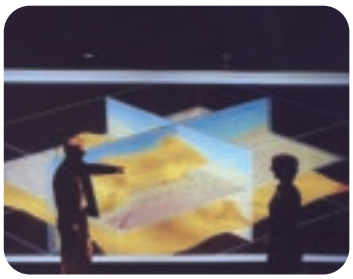

"We therefore added a CXFS layer developed by SGI, making it possible to share the centralized data, which then becomes directly accessible through the SAN. Each machine is responsible only for its own data. The system acts as a metadata server, indicating to the other machines the location of the data being searched for. The client machine then accesses the data directly, just as it would access its own data. In addition, when a metadata server is unavailable, another machine automatically takes over," Prim explains.

This SGI CXFS shared filesystem architecture ensures that the machines operate independently of each other for data access purposes. TotalFinaElf was therefore able to refocus the total power of all machines on computation, and the storage environment became much more compatible with the increasing capacity needs of the new surveys.

In the autumn of 2001, this architectural change was followed up by the installation of an SGI® Origin® 3800 server dedicated to 3D seismic applications and equipped with 64 500 MHz R14000™ processors and 64GB of memory. It replaced an Origin 2000 server with 32 300 MHz R12000™ processors and 32GB of memory. At the same time, TotalFinaElf took the opportunity to upgrade an Origin 2000 server dedicated to seismic processing from 48 195 MHz and 250 MHz R10000® processors to 32 300 MHz R12000 processors. Memory was also doubled from 16GB to 32GB. Finally, the buffer capacity under DMF was increased to 1TB.

"The net effect of all these changes was to provide us with a computing power (for seismic processing applications) of 120 processors, or approximately 103.2 GFLOPS, 116GB of memory, and 6TB of virtual disks. At the same time, applications for the computation of reservoirs and deposits, as well as R&D applications, now benefit from the computing power of 40 processors, or approximately 17.6 GFLOPS, with 35GB of memory and 94GB of disks," Prim says.

Immersive and Collaborative Environments: Making the Invisible Visible

A study of the physiology of human vision and the phenomena promoting visual perception enabled TotalFinaElf to determine the type and visual form in which data must be presented to the experts to facilitate their interpretive work. Three-dimensional representation of specially adapted models, by simulating reality, provides optimal conditions for comprehension. This 3D environment can be created either through stereoscopic vision or by rapid animation of models (at a rate of more than 15 images per second). In both cases, the ability to move in space in relation to the presented data facilitates comprehension.

"The key to effective, quick, and easy data interpretation lies in modeling, which displays abstract data in a state of palpable reality. The goal is to visually highlight that data which is significant from a petrophysical point of view. The strong amplitudes that are immediately apparent are not necessarily the most significant, but are only visual events. The major challenge of modeling is to make the invisible visible," states Xavier Payre, head of geoscience technologies, TotalFinaElf.

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SGI Equipment Makes it Possible

After examining the various possible technical solutions, the most appropriate one seemed to be a room equipped with a flat-tiled display wall measuring 5.8 meters by 2.5 meters and using a back-screen projection system with two video projectors to clone the interpretation stations already in use. TotalFinaElf based the design of the Geovision three-dimensional visualization complex on a complete analysis of the work modes and needs of future users.

When the decision was made to go ahead with the project by responding to specific needs, SGI was selected to supply part of the hardware and to provide integration services for the projectors in cooperation with Barco. SGI thus contributed its know-how to the implementation of this innovative project. The room has two dual-screen Silicon Graphics® Onyx2® workstations equipped with four 500 MHz R12000 processors and two InfiniteReality2™ graphics cards that share a memory of 4GB and 400GB of hard disks. Other additional dual-screen UNIX® and PC workstations are also part of the company's installed hardware base. Payre concludes by saying, "After 18 months of use, it is now possible to draw some preliminary conclusions from this experience. There is no doubt that this room enhances and facilitates collaborative work. It constitutes a veritable sphere of integration—both for the specialists, who are able to work together more easily, and for the data, which can be organized more coherently. Finally, this room provides an ideal environment for reflection and decision making on both the technical and managerial levels. The geosciences have evolved from the information sciences stage to the visualization sciences stage and as a result are more easily understandable by the majority. This represents an extraordinary potential for our industry."

In the Future: Optimizing Data Use by the Experts

"Our experts now fully appreciate the new level of computing comfort we have provided by making their data and projects more highly available and by significantly increasing computing power. We now plan to shift the emphasis to the use of the Geovision 3D virtual reality room, in order to develop new approaches that will enable our experts to make optimal use of the data they have analyzed, by immersing themselves in it. It is this project that will occupy us in 2002, with the help, once again, of SGI," Jacques Delvaux, geophysical operations and technology deputy manager of TotalFinaElf, says.

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3216 (06/26/2002)

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