INDUSTRIAL ASSOCIATES SYMPOSIUM

"Fluid Flow in Sedimentary Basins: A Distributed Network for the Interactive Control of Supercomputer Models"

April 11 & 12, 1989

Industrial Associates Program

AGENDA

Fluid Flow in Sedimentary Basins: A Distributed Network for the Interactive Control of Supercomputer Models

Rapporteur: Roger Anderson

Tuesday, April 11, 1989

9:00	Barry Raleigh Lamont	Welcome and Introduction
9:15	Larry Cathles Cornell	The "Overall Process Model" concept
9:45	Terry Bowers MIT/Harvard	Basins as Thermo-Chemical Reactors
10:15	Jeff Nunn LSU	Fluid Flow in the Louisiana subsurface
10:45	John Hunt WHOI	Pressure Bottles in the Subsurface
11:15	Roger Anderson Lamont	The "Data Cube" as input into the Supercomputer Codes
11:45	Jean Whelan WHOI	Organic Geochemistry & the Overall Process Model

12:30 Lunch

1:45	Bill Menke Lamont	The Distributed Computing Environment, Network Transmissions, and Broadcasts
2:15	Jeff Weissel Lamont	The Lamont Distributed Computational Experience

2:45 Gary Karner Lamont	The Lamont "Geobase" Distributed Database
3:15 John Mouton Landmark	The Landmark Workstation Controller "OpenWorks"
3:45 Jerry Baker CompCo	Computational Mechanics: Essentials and the Practice
4:15 Paul Manhardt CompCo	Template Concepts and the COMPSYS Code Capabilities
4:45 Bruce Land CNSF	The Cornell National Supercomputer Facility Visualization Program
5:15	Conclude
5:30	Drinks at the Director's Residence

Wednesday, April 12, 1989

9:00 Dave Caughey CNSF	The Cornell Theory Center and the National Supercomputer Facility (CNSF)
9:30 Martyne Hallgren CNSF	Networking at the Theory Center
10:00 Roice Nelson Landmark	Building an Interactive Geological Framework for Basin Research
10:30 Larry Cathles	Current Status of the Overall Process Model
11:00	Open Discussion
1:00	Lunch

Global Basins Research Network
? What Level of Collaboration and Cooperation ?

How Can Models and Data from the Network best be Communicated to Petroleum Industry Scientists?

A)Monitoring of progress through Industrial Associate meetings?

B)Workstation Nodes at your Lab with E-Mail?

C)Time on Cornell Supercomputer to try out Codes?

D)When Operational, Running of Proprietary Data (Remotely) through the Network's Models?

E)Visiting Scientists at the Network's University Centers?

F)Participation in Planning of Research Program?

FLUID FLOW IN SEDIMENTARY BASINS: A DISTRIBUTED NETWORK FOR THE INTERACTIVE CONTROL OF SUPERCOMPUTER MODELS

Industrial Associates Meeting
Lamont-Doherty Geological Observatory
April, 11-12, 1989

There are two fundamental and complex sets of problems that this Industrial Associates (IA) program will address. The first is development, operation, and management of a distributed network of geoscientists at distant locations in real-time. The second, and simultaneous, problem is the integration of cross-disciplinary scientific parameters, through a network, to/from supercomputer codes. Therefore, the IA meeting will consist of presentations and discussion from both the scientific and the computational perspectives.

Tuesday Morning, April 11

The Overall Process Model (Cathles, Bowers, Nunn, Hunt, Whelan, Anderson)

A sedimentary basin is a complexly interrelated system that is deformed and broken by tectonic forces, influenced by fluid geopressuring, and subjected to constantly changing fluid movements that produce active chemical changes. We wish to treat a sedimentary basin as a **thermo-chemical-structural reactor**.

Recent **developments in supercomputing, networking, and workstation technologies** allow us, for the first time, to interact with, and fully comprehend, the diversity of data in basins and to construct an overall model of basin processes. It is apparent that a basin model coupling physical and chemical processes can be developed and tested against real data.

In order to construct and test such an "Overall Process Model", we must combine diverse disciplines such as hard and soft rock geology, inorganic and organic geochemistry, petroleum, mineral and water resource exploration. The distribution of academic expertise requires that we **network** scientists from several universities together if we are to construct and successfully test such a model. Scientists from Lamont-Doherty Geological Observatory, Cornell University, Louisiana State University, the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution, in collaboration with International Business Bachines (New York), Computational Mechanics (Knoxville) and Landmark Graphics (Houston), are beginning a unified, multi-year effort toward the common goal of the development and testing of such an "Overall Process Model".

Tuesday Afternoon, April11

The Integrated Computing Environment (Menke)

Our objective is to establish an integrated computing environment, distributed across UNIX systems, for the study of overall processes in sedimentary basins. The two principal components of this environment will be: (1) a data collection and recording system based on UNIX workstations connected through local area networks and NSFNET, and (2) a model simulation system based upon real-time interaction between the CNSF supercomputer and the networked workstations. The scientists at the workstations will monitor and control the simulation in real-time. All components of the environment will be built using the socket abstraction provided by Berkeley UNIX, and protocols such as IP, UDP, RPC, NFS, x-windows, etc., layered over sockets.

The Workstation Network (Weissel, Karner)

The goal of the Landmark-based workstation network is to provide a mechanism for integrating the disparate geological data and models to derive a single subsurface interpretation. The network of workstations does this by allowing those involved in the project to develop and share a common database or "Data Cube." Though information is placed into the Data Cube from "control" workstations, all network workstations have the ability to communicate with the database and are able to display the data in immediately interpretable graphic form.

We have gained considerable expertise in integrating the graphic workstations, data bases, file systems, and interactive software that constitute a "Data-Cube" computing network during construction of the

Lamont GEOBASE. The Lamont computing system consists of >60 networked Sun/UNIX computers which share memory and computational load. Extensive Lamont databases, such as the worldwide records of earthquake locations and magnitudes, shipboard recordings of magnetic, bathymetric and gravity data, satellite databases of gravity and topography, core analyses and heat flow stations, are presently resident in the GEOBASE system. Data can be selected by dragging boxes over a map, and can be plotted in plan or cross-section.

The "Open Works" Controller (Mouton)

Communications between workstations in the case of the Basins Research Network is more complex because even more diverse kinds of data must be stored, manipulated, viewed compatibly, and interfaced with supercomputer codes in real-time. The "Open Works" architecture developed by Landmark was specifically designed to handle such tasks. Landmark intends to place its Open Works design in the public domain as a proposed standard for workstation networking and interaction software.

The Open Works architecture provides an environment that encourages integration of geological, geophysical, petrophysical, and engineering projects. It integrates software, including user-programmed applications abiding by certain standards, thus allowing all software to be highly interactive. Open Works and Landmark's additional workstation software allow, for example, easy interfacing with all databases, independent of format or kind (spatial or relational), easy reformatting of data for transmission to computers or output devices requiring specific formats, etc. The use of x-windows allows great flexibility in the Open Works architecture. Multiple windows can be created at the user's discretion, and each window can be tied to a specific executing program. Multiple windows can execute concurrently with one or more windows tied to each program. The windows can be reduced to icons for later recall. Communication between the application and its window uses session-level protocol, so that the program need not reside in the same computer as its window. A graphics workstation can thus present data in windows under the control of several programs running on a supercomputer.

Open Works augments x-windows by allowing screen-context information to be shared between programs, so that there is instant communication between related programs. For example a program running in one window can instantly update other related programs and their window displays with new information, as the user points to and selects data-related objects (such as a well log display) on the screen. In addition, Open Works presently supports a number of useful user functions such as command menus, pointing (mouse) and tracking, logical windows, notepads, sketchpads, database query functions that allow the user to access types of data such as geologic depths, interval thicknesses, temperatures, porosity values, etc., that were until now extremely time-consuming to recover.

The Landmark technology also provides an established mechanism for interactively connecting Landmark's advanced design workstation and the supercomputer at CNSF. When the simulation is running on a supercomputer, present technology will allow us to display graphical "snapshots" on a remote UNIX workstation every few minutes. Our goal is to display this "snapshot" in one window of a workstation while a second controls the simulation. Achieving this goal for the basin simulations requires considerable software development and will be made possible only by a collaborative effort between (1) workstation application programmers, especially at Lamont and Landmark, (2) developers of modeling algorithms, especially at Cornell and Computational Mechanics, and (3) network programmers, especially at Cornell and L-DGO.

The COMPSYS Supercomputer Codes (Baker, Manhardt)

The multiphase (water, gas, oil) fluid-flow models (which are based on conservation of mass and momentum) used to understand basins as **reactors** require the simultaneous solutions of well-known differential equations. The solutions of the equations are complicated, however, by the need to accurately model the large permeability variations between sand and shale, fault discontinuities, and other complications of real basins. These complications require different approximations at different scales of modeling, but on all scales require three-dimensional solutions which can treat both irregularly-shaped and abrupt permeability discontinuities. The most suitable solution for such problems is three-dimensional Finite Element Modeling (3-D FEM).

We plan to use one of the best of the commercially available 3-D FEM codes, and work with the developers of this code (Computational Mechanics) to apply it to modeling fluid flow and chemical alteration in basins, and also to explore more deterministic ways to model structural deformation. We choose to use commercial code in preference to home-grown code because commercial code is more transferable to other companies and users. It is generally better tested and documented. It is more professionally written and is maintained so it is always state-of-the-art. In addition, commercial codes are supported by staff, so new users always have someone to turn to when questions arise.

The COMSYS code was designed specifically to take advantage of parallel and vector supercomputer speed advances, and is operational on most popular serial machines as well as the Cyber-205 vector processor (ETA10) and the Control Data Cyberplus parallel (ring architecture) machines, and is currently being adapted to the Cray-2 computer at the NASA Ames Research Center. For the proposed project, COMSYS will be adapted for efficient operation on the IBM-3090-600E at the Cornell National Supercomputer Facility (CNSF).

Tuesday Afternoon and Wednesday Morning

Visualization with the CNSF Supercomputer (Land, Caughey, Hallgren)

To begin with, the communication network (currently at "slow" data transmission rates) will connect the workstations at Lamont, Cornell, LSU, MIT and Woods Hole through NSFNET. Basic communications protocols between the IBM computer and workstations are in place. Programming of software for remote cooperative processing will take ~1 year. Graphics software is currently under development which will receive the simulation grid from the supercomputers (through Open Works). Compression of data to minimize the use of the network will be a prime concern. Performance tuning of network communication protocols will likely be necessary. Supercomputer power is presently able to deliver data to the workstation only fast enough to update the model's Data-Cube every one to two minutes. No ray-tracing, ultra-high resolution, or manipulation of graphic views will be possible during an interactive run to begin with. These will be sequentially improved as the project progresses.

Interactive connection of the supercomputer to the high-end workstations is a goal which a number of academic and industry labs are working on (e.g., Los Alamos is developing a Cray to Gould/Unix interactive system). The success of this mode of computation-graphics interfacing is vital to the full utilization of supercomputing capability in all disciplines of science.

The Future Framework of the Overall Process Model (Nelson, Cathles)

The construction of an interactive geological framework for basin research is a difficult and complex task, combining the most advanced of geological concepts of how a basin works with the parallel supercomputer/ workstatin intercconnectedness of the future. We are interested in sharing with the IA our experiences in the planning and implementation of this ambitious project among geoscientists in diverse locations. We hope that by spending two days discussing the topics outlined above, we may learn from each other and prevent duplication.