CREWES computer systems*

Henry C. Bland and Darren S. Foltinek

ABSTRACT

This paper describes the computer systems and software used by the CREWES Project. The primary processing system, based on Sun-compatible hardware, is discussed in detail. This paper also mentions some of the PC based geophysical and mathematical processing packages used in research. Microcomputers and software used in generating the annual CREWES Research Report are also discussed. After a description of the CREWES network, the paper ends with two lists that detail the project's hardware and software.

INTRODUCTION

The CREWES Project's computer systems are an integral part of the project's research facilities. The primary uses of our systems are seismic data processing and interpretation. We use a variety of hardware and software combinations to aid in our research and actively pursue new hardware and software solutions to common geophysical problems. In cases where no solutions exist, our research involves developing new software. A secondary use of our systems is to aid in the preparation of papers and documents such as the annual CREWES Research Report.

SUN-COMPATIBLE SYSTEMS

Most of the project's computing requirements are met by a cluster of Sun-compatible, Sparc-CPU based systems running Sun's SunOS 4.1.4 operating system. The systems are connected together via an ethernet network to form this cluster. These systems are listed in Table 1.

Some of the systems were purchased by the University of Calgary's Department of Geology and Geophysics for teaching purposes. Thanks to the cooperation of the department, these systems are available for CREWES researchers during off-peak hours.

Even though the user environment is unchanged between systems, some have been configured specifically to deal with certain tasks. The system we use for seismic interpretation has two monitors. Interpretation applications make heavy use of screen real estate and they benefit greatly from two screens. The system used for 3-D processing requires large amounts of local disk space and random access memory. An Integrix Sparc 10 system has been configured with 60 gigabytes of disk space and 256 megabytes of memory specifically for this purpose. A Sun 670MP system is used as a central network server -- it acts as the NIS server, the domain name server, and the mail-hub for the department. Two systems, an Integrix Sparc 10 and a Sun Sparcstation 2 are used by CREWES staff for programming and modelling. Finally, a group of six Sun Sparcstation 2 are used by undergraduate and graduate students in laboratory sessions associated with Geology and Geophysics courses. These specialized systems are illustrated in Figure 1.

---

* This paper is a revision of previous years' computer systems reports

SEISMIC SOFTWARE PACKAGES

Advance Geophysical

Advance Geophysical has provided their full suite of processing packages: ProMAX 2D, ProMAX 3D, and ProMAX-VSP. ProMAX 2D is a complete UNIX-based environment for the analysis and processing of 2-D seismic data. It provides disk based and tape-to-tape input/output, parallel processing using multiple machines linked via a network, high resolution graphics, bitmapped color displays, links to various interpretive software systems and CGM+ hardcopy output. ProMAX 3D is a superset of ProMAX 2D which includes modules such as 3-D residual statics, 3-D one-pass migration, 3-D DMO, and 3-D interactive velocity analysis. ProMAX VSP includes tools for processing zero-offset and offset vertical seismic profiles.

In the past year, ProMAX has been upgraded from version 5.1 to version 6.0. The CREWES Project will be beta testing ProMAX 6.1, which will include modules for converted wave processing. These modules stem from prototype code developed at the CREWES Project in years past.

GMA

GMA has donated six complete GMA Explorational Software Systems to the University of Calgary. This software runs on PC-compatible systems and is available to CREWES researchers through the facilities of the Department of Geology and Geophysics. Their system includes the packages: STRUCT, LogM, Wave-X, and GrITS. Two of these packages, STRUCT and LogM, are modelling systems – one for structural modelling, and one for stratigraphic modelling. Wave-X is a wavelet extraction program that can interactively extract shaping or matching filters. The final program, GrITS, is used for stratigraphic interpretation of 2-D seismic data.

Hampson / Russell

Hampson-Russell Software Services donated a class-set of licences for their AVO, STRATA, and GLI3D software packages for UNIX. The AVO program is an interactive pre-stack AVO analysis and inversion package. It allows well-log plotting and editing, synthetic model building and AVO inversion. STRATA is an interactive post-stack stratigraphic analysis and inversion package, which allows model building, wavelet extraction and seismic inversion. Both AVO and STRATA include a processing module to allow post-stack processing, display and hardcopy output. The GLI3D package creates a near-surface geological model which is used to calculate static corrections for 2D and 3D datasets.

CREWES has been testing pre-release versions of AVO which include full elastic wave modelling. This new feature allows one to model interbed multiples and conversions. AVO's new INVEST feature uses a parabolic Radon transform to supress multiples and reduce noise.

Jason Geosystems

Jason Geosystems has supplied CREWES with the "DSite" and "Integrate" software products. DSite is an interactive velocity modelling tool based on generalized inversion theory. By combining seismic, well logs, and geology, DSite creates an interval velocity model that is consistent with both the input data and the geology.

"Integrate" allows the user to tie a well log to seismic data, and perform wavelet deconvolution. The data can be inverted using sparse spike or recursive trace inversion to create a detailed acoustic impedance model. Geological constraints can also be applied to the model to provide estimates of porosity, pay, and lithology.

Landmark

Landmark continues to support CREWES by providing the latest releases of all its applications. Among the software products we have received from Landmark are SeisWorks/3D, SeisWorks/2D, StratWorks, LogEdit, Syntool, Seiscube and Surfcube. SeisWorks/3D and SeisWorks/2D are seismic interpretation packages used for horizon picking, fault interpretation and correlation, seismic attribute analysis, and data display. Using SeisWorks one can display data with contours, in time slices, and with 3-D perspective. StratWorks is a geologic interpretation package used for stratigraphic correlation of well logs. With it, one can create cross sections, contours, and maps of picked horizons. The last two packages, LogEdit and Syntool perform well log editing and synthetic seismogram generation, respectively. Seiscube and Surfcube are programs which visualize 3-D datasets and features using perspective views.

Photon

Photon Systems (now merged with Cogniseis) continues to provide a class-set of licenses for their SeisX seismic interpretation package. This package allows one to display and interpret 2-D and 3-D data, map faults and horizons and visualize them in 3-D. Among its other features are grid balancing and interactive phase/amplitude matching between multiple surveys.

ADDITIONAL PC BASED SOFTWARE

Although our primary scientific workstations are UNIX-based, there are also a number of excellent MS-DOS based software packages which we use. MicroSeis' Outrider, Hampson-Russell's AVO and Strata and SIS's Vista and FDTools are examples of such geophysical packages. A number of others are listed in the software list at the end of this paper. The project also uses PC and Macintosh based packages for performing mathematics, statistics and graphing; however, they are used primarily for word processing and drafting.

PUBLISHING

Each year the work of the CREWES Project is summarized in its research report. The report is a very complex document, with contributions from a large number of authors. Each contributing paper typically includes diagrams, plots, pictures and tables. Assembling this document requires a great deal of effort, and each year we attempt to improve the report's quality and streamline the process. This year's research report has been assembled completely electronically, putting aside the traditional tools of scissors and tape. The benefit of this systems is that the entire report is available on compact disk. Chapter 46, "An introduction to the CREWES CD", discusses the contents of the CREWES CD in detail.

Several software packages are used to author the research report. The majority of the report is prepared using Microsoft Word for Macintosh and Microsoft Word for Windows. Diagrams are typically produced using Deneba Canvas on the Macintosh, and Corell Draw on the PC. Most graphs are generated in Mathworks Matlab - a mathmatical toolbox which includes a number of graphical analysis routines. Seismic

plots are usually creating by copying screen displays from seismic processing packages (such as ProMAX) and inserting these displays directly into the documents electronically. In the few instances where electronic graphics are unavailable, a colour scanner is used to import existing graphics into documents.

NETWORK

Our computer environment consists of networked workstations and personal systems which communicate amongst themselves, and with systems connected to the Internet. Our network is based on the Ethernet standard, running two common networking protocols: IP (TCP/IP) and Appletalk. These protocols support features such as file sharing, remote system access, printer sharing and electronic mail. The CREWES Project makes use of the LAN (local area network) running throughout the University's Department of Geology and Geophysics. This network is built with both coaxial cable and twisted pair cable, providing the electronic links between computers and networking hubs. These networking hubs provide signal conditioning and fault isolation so that the department's network can span four different floors of the Earth Science building while maintaining ethernet's top speed of 10 megabits per second (Figure 2b).

Beyond the departmental LAN there is a network that spans the campus of the University of Calgary. Each department of the University has its own subnetwork, and all the subnetworks are joined together through the central campus router. The university router is, in turn, connected to the Internet as shown in Figure 2a.

Most of the network activity between machines on our LAN is related to network file access. Almost all of the UNIX and MS-DOS computers are capable of using NFS (the Network File System). NFS allows disk drives, connected to any single computer, to be accessed from other computers on the network. Relying on NFS to access to remote files allows us to better utilize our pool of computers. Although our Macintosh systems don't support NFS, they too can share files using their own file sharing protocol called "Appleshare". All of our fileserver machines support filesharing using both Appleshare and NFS so that files are available from any machine on the network.

Email has become very popular within the department. All faculty, staff and graduate students have email accounts. The departmental mail hub processes over 112,000 electronic mail messages per year. This hub acts as a central depot for all email users; they can access their mail by logging into their Unix accounts, or read mail remotely from their personal PC and Macintosh systems. Our most popular email packages are Mailtool and Elm on the UNIX systems, PC-Eudora on PC systems, and Mac-Eudora on our Macintosh systems.

CONCLUSIONS

The CREWES Project has acquired a capable collection of computers and high quality software which allows it to carry out leading-edge research. Although this is largely due to the support of our sponsors, there are a number of companies who have chosen to donate their products to CREWES and the University. These donations are enormously helpful, and we thank these companies for their generosity.

ACKNOWLEGEMENTS

HARDWARE

Table 1. CREWES and Departmental Sun-compatible systems

Manufacturer	Model	CPU	Number of units and ownership
Integrix	Sparc 10 HS72-D	Dual Ross Hypersparc 72	1-CREWES
Integrix	Sparc 10 HS66-D	Dual Ross Hypersparc 72	1-CREWES
Cycle	Cycle 5	TI Microsparc 85MHz	1-CREWES
Sun	Sparcstation 2	Sparc 40MHz	1-CREWES
Sun	Sparcserver 670MP	Dual Cypress CY605	1-Dept.
Sun	Sparcstation 2	Weitek Doubler	4-Dept.
Sun	Sparcstation 2	Sparc 40MHz	1-CREWES, 2-Dept

Table 2. Tape drives

Quantity	Model
1	Exabyte 8200 8mm
2	Exabyte 8505 8mm
2	Archive Viper QIC
4	Archive Python 4mm*
1	Storage Tech. 1950 9 track*

Table 3. Plotters

Model	Description
Versatec C2700*	colour thermal plotter
Versatec 8242A	42" electrostatic plotter
Versatec 8224*	24" electrostatic plotter
Versatec ECP42*	42" colour electrostatic plotter
Versatec 3224	24" colour electrostatic plotter
Versatec 8944	42" colour electrostatic plotter

Table 4. Personal Computers

Quantity	Model
1	Apple Power Macintosh 6100
2	Apple Power Macintosh 7100
4	Apple Power Macintosh 7200
3	Apple Macintosh IIsi
1	Apple Macintosh SE/30
2	Apple Powerbook 180*
2	IPC 486/66*
1	IPC Pentium*
1	Packard Bell 386/33*
1	Zenith 386/33*

---

* Indicates equipment made available to CREWES by the Department

SOFTWARE LIST

The following list describes all the software we use on a regular basis. This list excludes system software, compilers, system utilities and lesser-used software. Although care has been taken in preparing this list, it is likely that portions of the list are inaccurate or out of date. For this reason, this list should be considered a guideline only, and not a source of authority for product information.

Modelling			
Package	Vendor	Description	Operating System
LogM	GMA	Well log based seismic modelling; display & edit well logs, synthetics, geologic & seismic cross-sections	MS-DOS
STRUCT	GMA	Seismic modelling of structural geology using vertical incidence or normal incidence ray tracing or diffraction modelling	UNIX and MS-DOS
AVO	Hampson and Russell	Interactive AVO modelling, analysis, and inversion.	UNIX and MS-DOS
GLI3D	Hampson and Russell	Static corrections using a near-surface geological model	UNIX
DSite	Jason Geosystems	Velocity modelling based on Generalized Inversion Theory	UNIX
Integrate	Jason Geosystems	Seismic inversion to an impedance model using sparse spike or recursive trace	UNIX
Outrider	MicroSeis Technology	Multicomponent modelling	MS-DOS and UNIX
MIMIC	Sierra	Geologic modelling and mapping; preparation of models for ray tracing	UNIX
QUIK	Sierra	2D & 3D seismic ray tracing field short records, CMP gathers, stacked sections before and after time migration, VSP, P, S, and converted waves.	UNIX
VESPA	Sierra	Wave equation migration; shot records, VSPs, offset VSPs	UNIX
SLPR	Sierra	Display of results on screen or hard copy	UNIX

Processing			
Package	Vendor	Description	Operating System
ProMAX ProMAX 3D	Advance Geophysical (Landmark)	Complete 2-D, 3-D processing package.	UNIX
ProMAX VSP	Advance Geophysical (Landmark)	VSP processing system	UNIX
Insight	ITA (Landmark)	Complete processing package	UNIX
Vista	Seismic Images Software	Interactive seismic processing from shot record to final stack, synthetic seismograms.	MS-DOS
FDTools	Seismic Images Software	Design 3D surveys, acquisition parameters	MS-DOS
Vista Vision	Seismic Images Software	Seismic plotting program for Vista output files	MS-DOS
STRATA	Hampson and Russell	post-stack stratigraphic analysis and inversion package, model building, wavelet extraction, seismic inversion	UNIX and MS-DOS

Interpretation			
Package	Vendor	Description	Operating System
GrITS	GMA	Stratigraphic interpretation of 3-D seismic data	MS-DOS
SeisWorks/3D SeisWorks/2D	Landmark	Seismic interpretation with horizon picking, fault interpretation and correlation, seismic attribute analysis and data display	UNIX
StratWorks	Landmark	Geologic Interpretation	UNIX
3DVI (SurfCube, SeisCube)	Landmark	3-D seismic visualization	UNIX
SeisX	Photon	2-D and 3-D seismic interpretation and visualization	UNIX

Mathematics			
Package	Vendor	Description	Operating System
Matlab	Mathworks	Mathematics and statistics package with 2D and 3D graphing capability	UNIX and MS-DOS
Theorist	Prescience	Mathematics and statistics package with 2D and 3D graphing capability	Macintosh
Cricket Graph	Cricket Software	Graphing; simple statistics and data manipulation	Macintosh

Well Log Analysis			
Package	Vendor	Description	Operating System
Wave-X	GMA	Wavelet extraction from well logs	MS-DOS
LogM	GMA	Entry, computation and management of well logs. Can generate synthetic seismograms.	MS-DOS
LogEdit	Landmark	Well log editing	UNIX
Syntool	Landmark	Synthetic seismogram generation	UNIX
LAS	Petcom	Log editing, crossplots and petrophysical analysis	MS-DOS

Document Processing			
Package	Vendor	Description	Operating System
Acrobat	Adobe	Electronic publishing.	Macintosh
Corel Draw	Corel	Drawing, slide making	MS-DOS
Word	Microsoft	Word processing with equation capability	Macintosh MS-DOS
Wordperfect	Wordperfect Corporation	Word processing with equation capability	Macintosh MS-DOS
Expressionist	Waterloo Maple Software	Visual mathematical equation editor	Macintosh
Canvas	Deneba	Drawing, slide making	Macintosh
Photoshop	Adobe	Scanning and image processing	Macintosh

Miscellaneous			
Package	Vendor	Description	Operating System
Seismic Data Loader	Panther	Simple data loading into Landmark SeisWorks. Tools for manipulating and displaying SEG-Y files.	UNIX
Rat	Digirule	Digitizing of well logs, seismic horizons, etc.	MS-DOS
AXXSES	Digtech	Modem access to well data (locations, tops, production, cores, etc.) and well-log digits.	MS-DOS

Networking			
Package	Vendor	Description	Operating System
BW-NFS	Beame and Whiteside	TCP/IP software, including Telnet, FTP, and NFS. Also supports network printing.	MS-DOS
CAP	None	Appletalk support for UNIX systems. Supports file sharing, printing services, and backup	UNIX
Eudora	Qualcomm	Internet Electronic mail with full graphical user interface.	Macintosh MS-DOS
HCL-eXceed/W	Hummingbird Communications	X-Window server software for PC's under Microsoft Windows	MS-DOS
Netscape	Netscape Communications	World Wide Web browser	UNIX Macintosh MS-DOS

The CREWES Project

Interpretation Workstation
Sparcstation 5

3-D Seismic
Processing
Sparcstation 10 HS72

3-D Seismic
Processing
Sparcstation 10 HS 66

Software Development
Sparcstation 2 and X Terminals

Seismic applications
and Word processing
**Macintosh PowerPCs and
PC Compatibles**

Physical Modelling System
PC Based acquisition controller

Ethernet
network hub

Lithoprobe
Seismic Processing
Facility

Other University of
Calgary Departments

Internet

**The Foothills
Research Project**

Structural Geology
Visualization
Sparcstation 20 ZX 3-D engine

Structural Geology
Interpretation
Pentium PC Compatibles

The Department of Geology and Geophysics

Network Information and mail server
Sparcserver 670MP

Seismic processing laboratory
Sparcstation 2

Math Sciences Building

Computing Services Systems

FDDI 100 MB/s

Campus Router

Ethernet over fiber 10 MB/s

To other departments on U of C campus via ethernet

To the Internet via ARNET and CA*NET

Art Building

Campus ATM Switch

ATM over fiber 155 MB/s

Telco Main Office (Calgary)

High Performance Computing Centre (Calgary)

AGT Calgary ATM Switch

HPCC Router

To WNET (an ATM testbed network connecting sites in Edmonton, Regina, Winnipeg, Vancouver)

Dual Ethernet

Fujitsu VPX 240

Earth Sciences Building

5th floor

| Concentrator 10 Base T | Concentrator 10 Base T | Concentrator 10 Base T | Concentrator ThinNet |

Faculty / Staff offices

Graduate student offices

PC lab & Geochemistry group

2th floor

| File Server / Router | Concentrator ThinNet | Appletalk Bridge |

CREWES Systems & Seismic Processing Lab

Main Floor

| Concentrator 10 Base T | Concentrator 10 Base T |

Department office

Faculty / Staff offices

Basement

| Concentrator ThinNet |

Modelling lab and staff offices