

CREWES computer systems*

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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 Solaris 1.1 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.

The cluster is configured to make the user environment as consistent as possible from one workstation to another. Even though applications programs and data files reside on different systems in the cluster, they can all be located through consistent and universal directory names. This is accomplished using network services such as the Network Information Service (NIS), the Network File System (NFS) and the AMD automounter.

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

Even though the user environment is unchanged between systems, some have been configured specifically to deal with certain tasks. The system we use for Landmark's applications has two monitors. The Landmark applications make heavy use of screen real estate and they benefit greatly from two screens. 3-D processing requires large amounts of local disk space and random access memory. A Sparc 10 has been configured with 41 gigabytes of disk space and 256 megabytes of memory specifically for this purpose. The Sun 670MP system has three ethernet network interfaces so that it can route network traffic between different networks in the department. This centrally-located system is designated a network server -- it acts as the NIS server, the domain name server, and the mail-hub for the department. Finally, a group of six Sparcstation 2's are used by undergraduate and graduate students in laboratory sessions associated with Geology and Geophysics courses. These specialized systems are illustrated in Figures 1a and 1b.

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 interactive and batch environment for the interactive and batch 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.

We switched from the ITA INSIGHT processing package to ProMAX one year ago. Some researchers are still using INSIGHT to finish projects that were started with INSIGHT, but the conversion to ProMAX is practically complete. We found that the switch has significantly improved our productivity. We also find that students require much less help learning ProMAX than learning INSIGHT.

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 number 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.

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.

Petcom

Petcom Software and Services has provided their well log analysis package, LAS. This program runs on IBM PC compatible systems and can edit logs, create crossplots and perform petrophysical analysis, including porosity, water saturation, complex lithology and shaliness estimations.

Outrider

MicroSeis Technology has donated the Outrider geophysical/geological modelling program. Outrider can be used to create complex geological or seismic models, and can perform either forward or inverse modelling.

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. 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. One of the most popular Macintosh packages we use is Deneba's Canvas. This software is used for making drawings for the CREWES Research Report, as well as slides and overheads for the annual CREWES sponsors' meeting and tutorial days.

Document preparation

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 some papers will be converted into a format that can be published electronically over the internet network (see chapter 20, "Electronic Documents and the World Wide Web).

Several software packages are used to author the research report. The majority of the report is prepared on Apple Macintosh computers using Microsoft Word and Aldus Pagemaker for word processing. Many of the diagrams are produced using Deneba's Canvas drawing package, while most graphs are produced by Cricket Graph or Matlab. A number of images were scanned from paper originals using a flat-bed scanner and Adobe Photoshop software. A smaller portion of the report was generated using PC word processing packages, such as Wordperfect and Microsoft Word for Windows.

NETWORK

Our computer environment consists of networked workstations and personal systems which communicate amongst themselves, and with systems connected to Internet¹. 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 2).

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 2.

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. Whereas NFS

¹ The Internet is a network that connects universities, commercial organizations and research organizations around the world

services are bundled with Sun's operating system, MS-DOS and MacOS² do not contain NFS support. To allow MS-DOS machines to use NFS, we purchased a product called BWNFS by Beame and Whiteside. Although software can be purchased for our Macintosh systems to work with NFS, we have decided to make our Sun systems Appleshare compatible. "Appleshare" (to be discussed later) is Apple's non-compatible equivalent to NFS. The union of NFS and Appleshare on our network give us complete file sharing capabilities.

The Appletalk networking protocol shares some of the features of the IP protocol; file sharing (called Appleshare), client/server communications, and printer sharing. Using the CAP Appletalk software for our Suns, the Sun systems can be used as file servers for our Macintoshes. Users save their Macintosh files directly into their accounts on the Sun systems in the same manner that they would store their files on a personal floppy disk. This system allows us to backup all our users' files from one central location. The Sun systems benefit from Appletalk as well. Using the Appletalk protocol, the Sun systems can print to any of the Appletalk network printers, such as our Apple LaserWriter printers.

At present, the departmental mail hub processes over 35,000 electronic mail messages per year. The departmental mail server acts as a central depot for all email users, though many users access their mail from their personal PC and Macintosh systems. Our most popular email packages are Mailtool and Elm on the UNIX systems, PC-Eudora or Trumpet on our MS-DOS systems, and Mac-Eudora on our Macintosh systems. We have found email a vital tool for communicating within our research group. We make daily use of email for communicating with other researchers, software companies, and sponsors around the world.

In the past year we have found that our seismic datasets have grown significantly, probably due to the processing of more 3-D datasets. Whereas last year our aggregate disk space totalled 15 gigabytes, our disk space now totals over 60 gigabytes. Even though we make efforts to process large datasets on locally-connected disks, we frequently need to transfer these large datasets over our network. We are finding that the speed of our Ethernet-based network is insufficient to handle the increased load. In the year to come, we will be looking at higher-speed network technologies such as "fast ethernet" and ATM to satisfy our network demands. CREWES is also participating in a project to connect several Universities in Western Canada via a high-speed ATM network. The campuses of the University of Calgary and University of Alberta are already connected via an ATM link, and we shall soon have this ATM network reach one of our systems (Figure 2).

CONCLUSIONS

The CREWES Project has acquired a capable collection of computers and high quality software which allows it to carry out leading-edge research. We would like to thank both our sponsoring companies and those companies who have donated software and hardware. These donations are enormously helpful, and we thank these companies for their generosity.

²The operating system that runs on an Apple Macintosh computers

ACKNOWLEDGEMENTS

We would like to thank the Department of Geology and Geophysics for providing access to its computer facilities and Malcolm Bertram for his assistance in maintaining the computer systems. Thanks also to Tina Howell, Susan Miller and Mark Lane who have helped maintain the software list that is included in this paper.

HARDWARE

Table 1. CREWES and Departmental Sun-compatible systems

Manufacturer	Model	CPU	Number of units and ownership
Aries	Sparc 10 HS72-D	Dual Ross Hypersparc 72	1-CREWES
Aries	Sparc 10/40	TI Supersparc	1-CREWES
Sun	Sparcserver 670MP	Dual Cypress CY605	1-Dept.
Sun	Sparcstation 2	Weitek Doubler	4-Dept.
Sun	Sparcstation 2	Standard	1-CREWES, 2-Dept
Sun	Sparcstation 1+	Standard	1-CREWES

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

Table 4. Personal Computers

Model
Apple Macintosh IIsi (3)
Apple Macintosh SE/30
Apple Powerbook 180* (2)
IPC 486/66*
IPC Pentium
Packard Bell 386/33*
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 its preparation, it is likely that portions of the list are inaccurate or out of date. For this reason, it should be considered a guideline only, and not a source of authority for product information.

Modelling			
Package	Vendor	Description	Operating System
UNISEIS	Applied Geophysical Software inc.	2D Ray-trace modelling for offset, normal incidence, normal emergence, VSP, or crosshole geometries. P, S and converted waves	AIX (RT)
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
ProVSP	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
FTools	Seismic Images Software	Design 3D surveys, acquisition parameters	MS-DOS
Vista Vision	Seismic Images Software	Seismic plotting program for Vista output files	MS-DOS
PCVSP	Kostelnick	One layer crosswell & VSP ray tracing	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

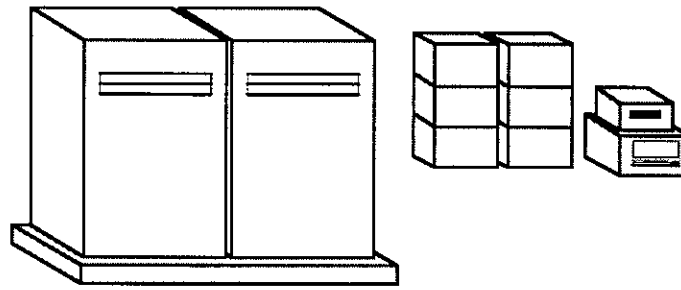
Document Processing			
Package	Vendor	Description	Operating System
Corel Draw	Corel	Drawing, slide making	MS-DOS
Word	Microsoft	Word processing with equation capability	Macintosh MS-DOS
Wordperfect	Wordperfect Corporation	Word processing with equation capability	MS-DOS
Expressionist	Allan Bonadio Associates	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
HCL-eXceed/W	Hummingbird Communications	X-Window server software for PC's under Microsoft Windows	MS-DOS
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

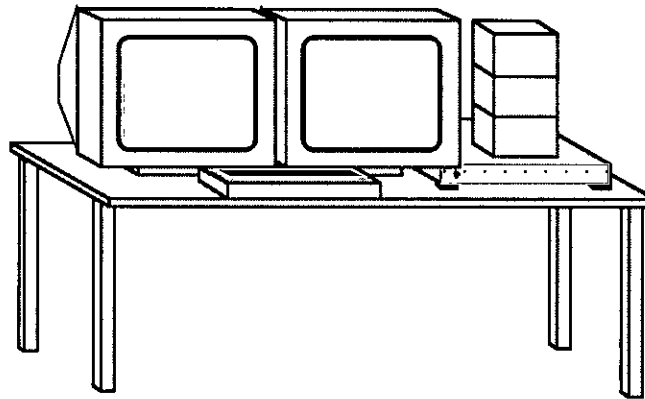
**Network Server,
Mail Server and
I/O Server**

Sun 670MP
3 Ethernets
15 GB Disk
Exabyte/DAT
9 Track



**Landmark
SeisWorks
Interpretation**

Sparc 2
4 GB Disk
Exabyte



**Promax 3-D
Processing**

Sparc 10/72 Dual
41 GB Disk
256 MB RAM
Exabyte

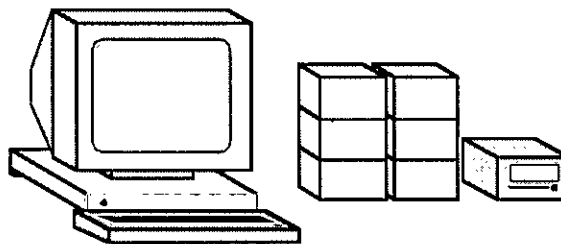
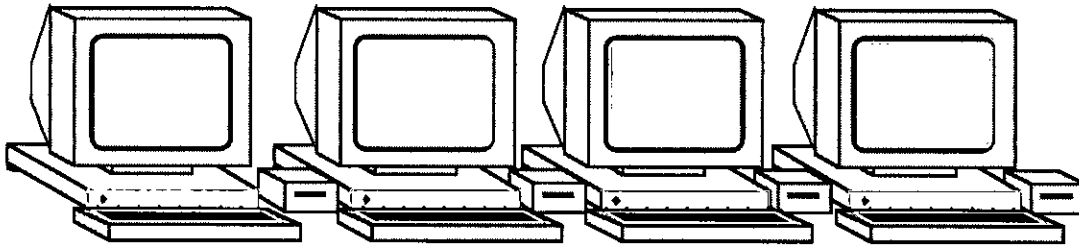
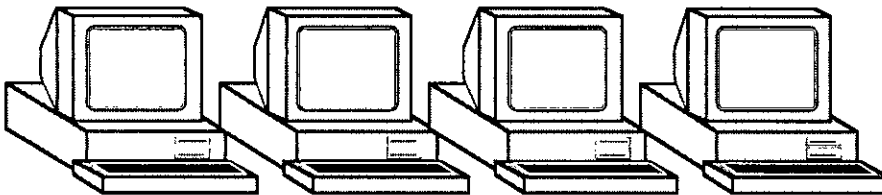


FIG. 1a. Specialized Computer Systems



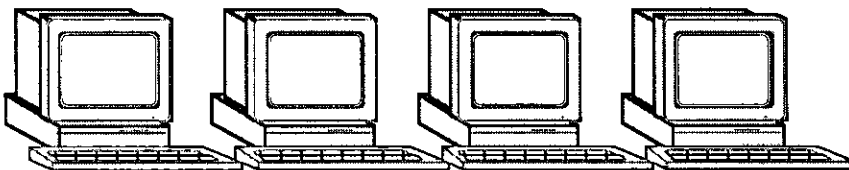
Seismic Processing Lab

Six Sparc 2 / 800 MB Disk / DAT
Promax / Hampson-Russel (Strata GLI-3D AVO)



PC Lab

Seismic Processing Lab
Ten 386/486 PCs
GMA, VISTA, Outrider, etc...



Document / Paper writing lab

4 - Apple Macintosh

FIG. 1b. Specialized Computer Systems (continued)

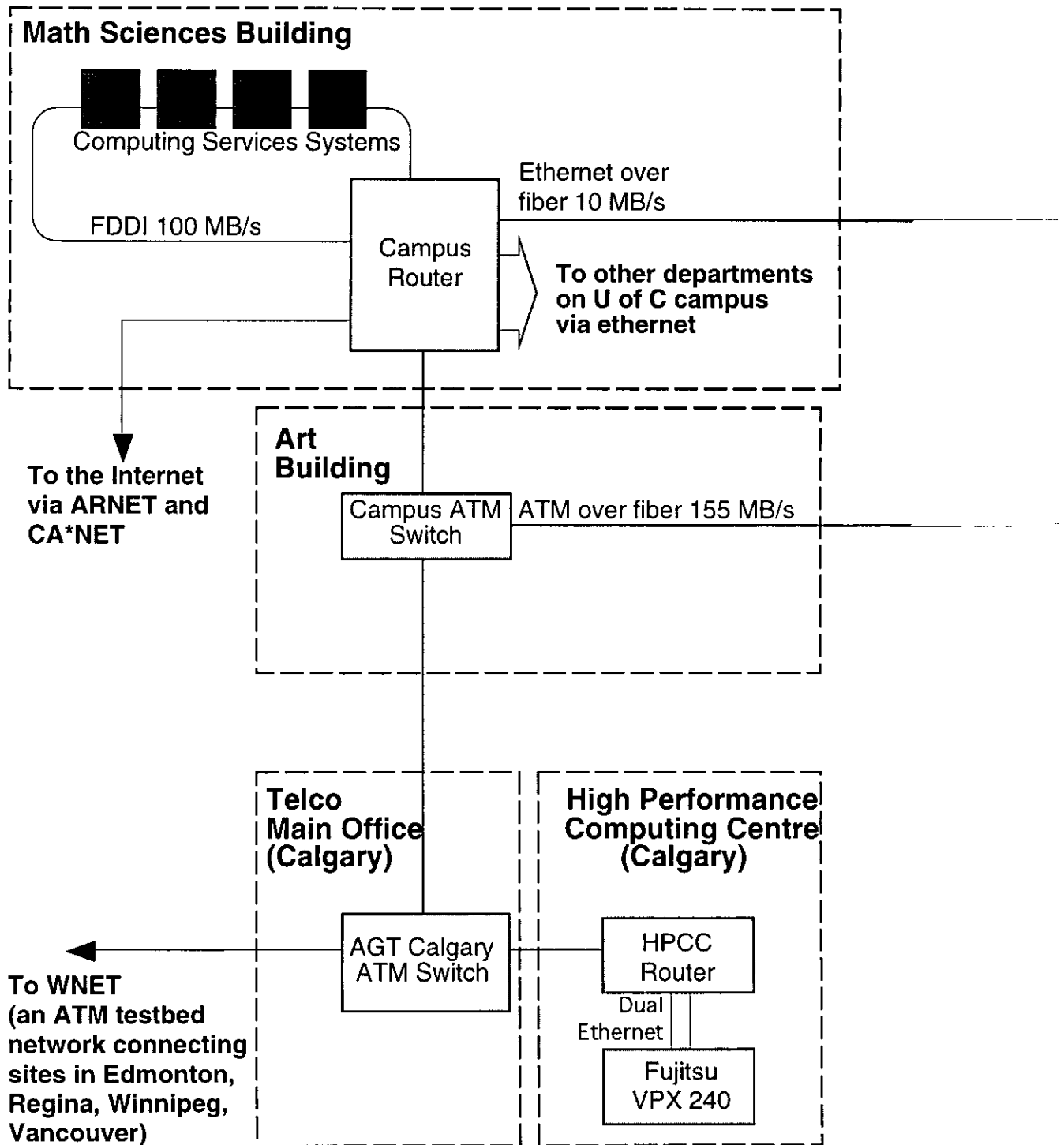


FIG. 2a. University / External Network

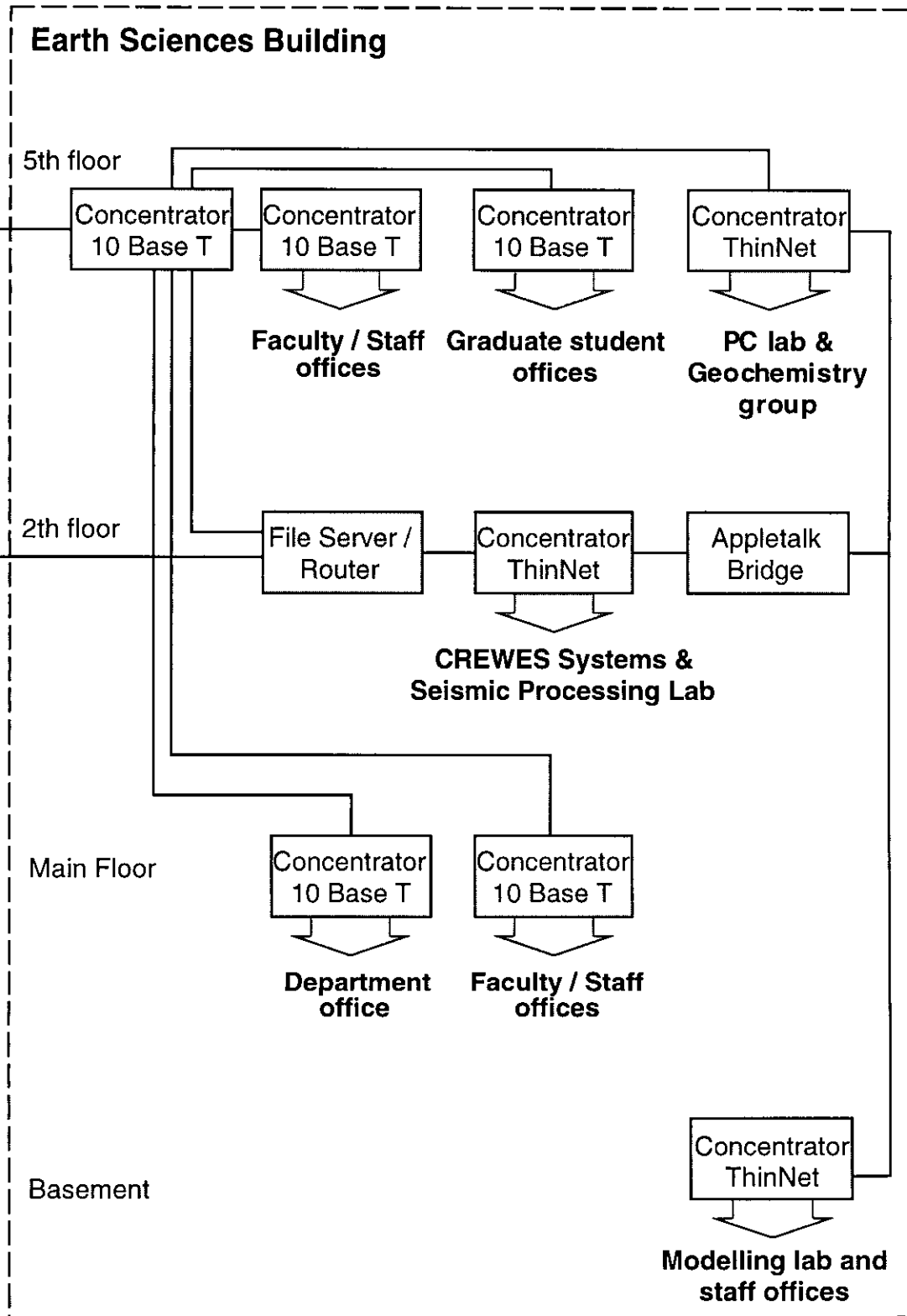


FIG. 2b. CREWES / Department Network