Bureau of Mineral Resources, Geology & Geophysics

R E C O R D

Record 1991/97

PC X11 Windows Servers Providing Network Access to UNIX Graphics

Prame N Chopra
Information Systems Branch

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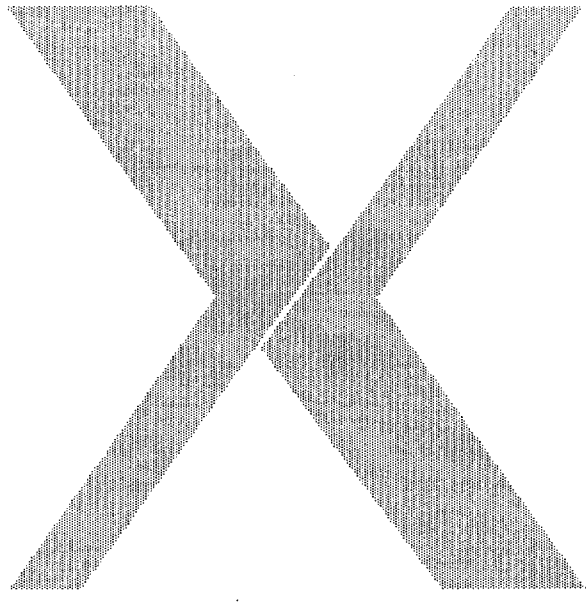

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ISSN 0811-062X
ISBN 0 642 16878 4

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Abstract

The X Window System, Version 11 (usually referred to as X11 or X11 Windows) is a hardware independent, operating system independent, graphics environment developed by the Massachusetts Institute of Technology. X11 is particularly effective when it is used over a network (such as BMR-Net) because it allows applications running on different host computers on the network to be accessed locally even if the hosts concerned are of different types and use widely different operating systems. Both the ER Mapper image processing package and ArcInfo Rev. 6 operate under X11 and it is therefore possible to network these applications throughout BMR using X11.

There are currently a number of software packages available for IBM-compatible PCs which effectively turn these machines into "smart" X11 terminals. This software provides a relatively inexpensive means of providing BMR scientists who already have access to suitable PCs, with network access to ER Mapper and shortly to ArcInfo (when Rev. 6 becomes available). This Record assesses the performance and relative merits of 3 X11 server packages for IBM-compatible PCs (viz. HCL-eXceed/W, XVision and X11/AT).

Of the three X11 servers tested, one stands out as being best for BMR's applications. This product, HCL-eXceed/W provides the kind of save-under and restore-from-icon functionality that is needed in order to painlessly run UNIX applications such as ER Mapper (and ArcInfo Rev. 6) on remote PC workstations. HCL-eXceed/W is not as fast at screen drawing operations as XVision though this may, at least in part, be due to the higher overheads it has in correctly performing save-unders. HCL-eXceed/W does however draw its screens faster than the other product, X11/AT.

Both XVision and X11/AT fail to provide proper local screen management of graphics windows (such as ER Mapper images). In both cases, the content of graphics windows which become obscured by impinging menus and other windows are lost. The entire obscured window must then be redrawn by the remote UNIX host in order to restore the data that have been lost in this way. This redraw imposes a substantial penalty both in terms of the time it takes and in terms of the substantial unnecessary ethernet network traffic which it generates.

The installation procedures for HCL-eXceed/W are considerably more complicated than those for XVision and X11/AT. Similarly, the configuration (and reconfiguration) procedures for HCL-eXceed/W are also less integrated and less intuitive than are the equivalent procedures for the other two X11 servers. These shortcomings should be improved in future releases of HCL-eXceed/W (the version examined was 1.0) but in the meantime they can be circumvented with a detailed installation and configuration manual for BMR users (Chopra, 1991b).

Introduction

Access to BMR's major information technology (IT) systems over the BMR-Net ethernet network is becoming an important issue. Network users need access to much if not all of the functionality that is provided to users working on the principal workstations associated with each system (Chopra, 1991a). For example, the ER Mapper image processing package which can be run in the Image Processing Centre on a SUN Microsystems workstation needs also to be available over BMR-Net to PC users. Similarly, network access to the ArcInfo geographic information system (GIS) is needed if the system is to be widely used.

Fortunately network access of this kind can be implemented using the X11 Windows system developed by the Massachussetts Institute of Technology.

The X Window System, Version 11 (often referred to as X11 or X11 Windows) is a hardware independent, operating system independent, graphics environment. Central to X11 is the concept of the **X display server** and the **X client**. The X display server is a special application which runs on a computer or terminal and controls its display screen. This X server manages windows opened on the screen and manipulates the graphics and text displayed within them. These windows can be initiated either by the actions of the user or by applications running on remote host computers connected via a network. An X client is an application program (e.g. a spreadsheet or an image processing program such as ER Mapper) that communicates with an X server in order to display its outputs. Communications between the X server and its X clients is accomplished through X11 commands

X11 is particularly effective when it is used over a network (such as BMR-Net) because it allows applications running on different host computers on the network to be accessed locally even if the hosts concerned are of different types and use widely different operating systems.

There are currently a number of software packages available for IBM-compatible PCs which effectively turn these machines into "smart" X11 terminals. This software provides a relatively inexpensive means of providing BMR scientists who already have access to suitable PCs, with network access to ER Mapper and (shortly) to ArcInfo.

The X11 software packages for PCs fall broadly into two camps. There are a number of packages which operate from MS-DOS and provide X11 Windows functionality. These packages operate either by using only the 640 Kbytes of Random Access Memory (RAM) directly addressable by MS-DOS (e.g. PC-XView, HCL-eXceed) or by using a DOS extender to address high memory (e.g. PC Xsight, HCL-eXceed Plus, HCL-eXceed Plus/8514A, PC-XView/16). The other camp includes software packages which operate from within the Microsoft Windows 3 shell which itself runs on top of MS-DOS. Packages in this category include HCL-eXceed/W, XVision and X11-AT.

After careful consideration I decided that the latter type of software (i.e. X11 emulators running under Microsoft Windows 3) offered a better solution for BMR. Two major benefits accrue from using these Microsoft Windows 3 packages. Firstly, Microsoft

Windows 3 provides a device independent graphic interface which is supported by most graphics card manufacturers. Hence almost any existing graphics card can be used on a PC to run X11. Secondly, the remote UNIX host is not responsible for management of the X Windows opened on the PC. This screen management function is handled by Microsoft Windows 3 itself. This has four benefits: it cuts down dramatically on network traffic, it reduces the load on the remote UNIX cpu, it makes for rapid screen repainting and lastly, it provides a very easy to use cut and paste facility between the X11 session and Microsoft Windows applications.

Configuration & Performance

Each of the 3 Microsoft Windows-based X11 emulators was installed on an 80386 IBM-compatible PC clone in order to test their functionality, ease of installation and robustness. The PC concerned operated at a clock speed of 25 MHz and had an 80387 maths co-processor, 8 Mbyte of RAM, a Tseng Labs Mega Eva/1024 super VGA display adapter and a Logitech 3 button bus mouse. The PC already had MS-DOS 4.01 and Microsoft Windows 3.0 installed. TCP/IP ethernet protocols were provided by SUN Microsystems PC-NFS version 3.01.

HCL-eXceed/W configuration

An evaluation copy of HCL-eXceed/W (version 1.0) was provided by Information Network Solutions Pty Ltd of Artarmon, NSW. The software is a product of Hummingbird Communications Ltd. of Markham, Ontario, Canada.

Minimum hardware and software requirements:

. an IBM PC 80286, 80386 or 80486 or compatible
. Microsoft Windows version 3 in either standard or 386 Enhanced mode
. 2 Mbyte of RAM
. an EGA, VGA, super VGA or 8514A display adapter
. a colour monitor (essential for image processing applications) or an analog monochrome monitor
. a mouse (preferably 3 button) and a mouse driver compatible with Microsoft Windows 3
. a hard disc
. an ethernet network card
. TCP/IP software compatible with the network card from the following list:
    - 3Com 3+Open TCP
    - Beame & Whiteside NFS or Telnet
    - Excelan LAN WorkPlace
    - FTP PC/TCP
    - HP ARPA Services
    - Novell LAN WorkPlace
    - SUN PC-NFS
    - Ungermann-Bass TCP BNS/PC
    - Wollongong PathWay for DOS
    - Wollongong WIN/TCP for DOS

Installation of the software was relatively straightforward. An install program was provided on the distribution disc and this was run from the MS-DOS command line (not from within Microsoft Windows). The install program copies the necessary files to the hard disc and makes the required additions to the autoexec.bat file. With the 100 dot per inch X fonts installed, HCL-eXceed/W required a total of 4.69 Mbyte of hard disc storage. This figure does not include the storage requirements of the TCP/IP transport software (e.g. PC-NFS which uses 1.49 Mbyte).

The user must manually create a new program group for HCL-eXceed/W in Microsoft Windows and must then manually insert the necessary programs into this group (XceedW, XStart and XconfigP). This is not a difficult task for an experienced Microsoft Windows user, but it really should be handled by the installation program (as it is for the other two products discussed below).

Configuration of the software is managed by a menu driven program called XconfigP which can be run either from within Microsoft Windows or from the MS-DOS command line. The configuration options for HCL-eXceed/W are the most extensive of the three packages reviewed. This means that HCL-eXceed/W is the most powerful of the packages, but it is also more time consuming to set up and this set up is more difficult for the novice user.

ER Mapper Version 2.0 requires a particular X11 font called **d12lucida.snf** and HCL-eXceed/W (as with the other two packages) did not directly support this font. It was therefore necessary to establish a font alias so that the X11 server on the PC would substitute another suitable font when ER Mapper requested d12lucida. This font aliasing procedure was quite complex for HCL-eXceed/W.

HCL-eXceed/W Performance

HCL-eXceed/W performed very well once it was correctly configured in multiple windows mode. With the backing store option set to "when mapped" the contents of all visible windows (including ER Mapper images) were always preserved locally whenever another window such as a pop-up menu impinged. Once the obscuring window was removed (e.g. by closing it or by moving it), the underlying window was quickly and automatically repainted (see Figs. 1-3). Similarly, any image window which was minimised to an icon and then was subsequently re-opened, did so with its image intact.

This type of functionality is essential when running an application such as ER Mapper. This particular software places many menus and image windows on the screen and the user is constantly having to shuffle from one menu or image window to another. By saving all obscured windows in local PC memory and updating the screen from this source, network traffic is reduced and time consuming screen refreshes are minimised. There are however two drawbacks. Firstly, the PC requires more memory than it otherwise would, and secondly, screen drawing functions can be a little slower. The latter problem is illustrated in Table 1 where screen drawing rates for HCL-eXceed/W are compared with those for XVision and X11/AT.

Table 1 Performance Data for three PC X11 Servers

Software	Small window graphics	Full screen graphics	Text mode drawing
HCL-eXceed/W	9.8 seconds	39.4 seconds	12.0 seconds
XVision	6.7 seconds	24.4 seconds	5.2 seconds
X11/AT	10.7 seconds	50.4 seconds	6.6 seconds

These performance data were obtained by running ER Mapper on each X11 server. The graphics drawing times were obtained using a 3 band rgb image. The text mode times were obtained by timing drawing of the ER Mapper "Load Algorithm" menu.

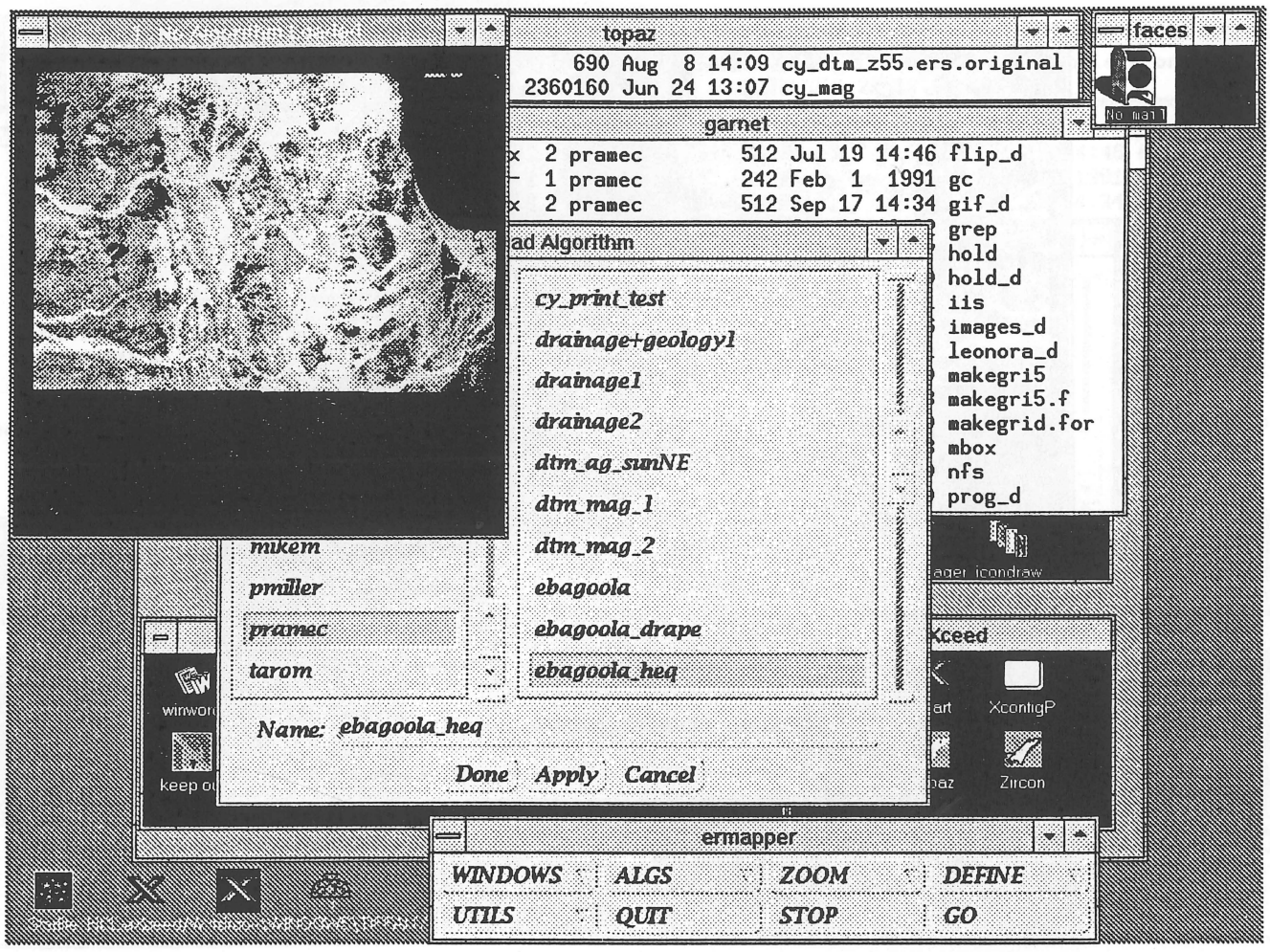

Figure 1 A screen captured during an X11 windows session with HCL-eXceed/W and the ER Mapper image processing software. Note how multiple UNIX logon sessions can be viewed and worked with. Here sessions are open on the GARNET and TOPAZ SUN 4/280 file-servers.

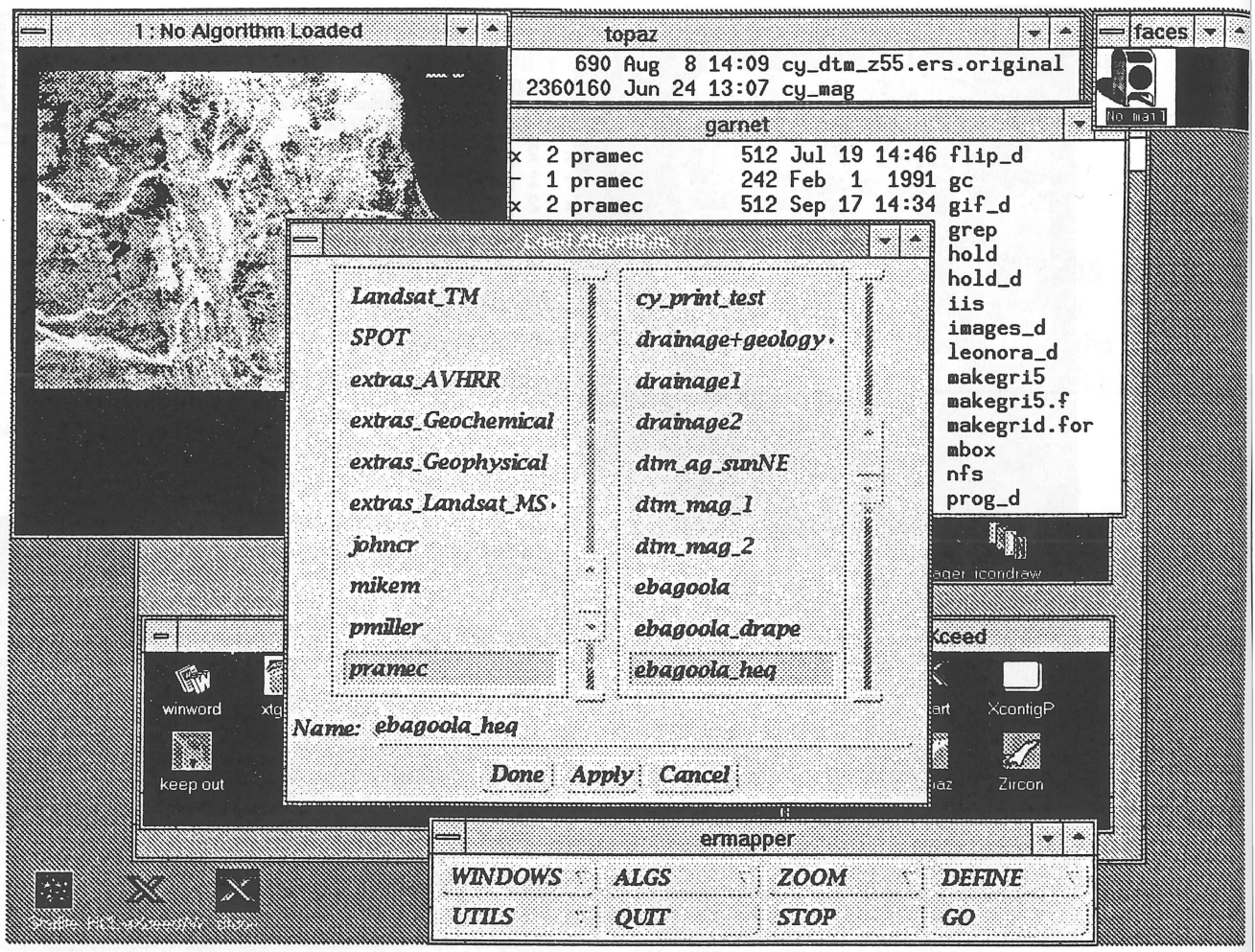

Figure 2 In this screen using HCL-eXceed/W, the ER Mapper image window has been temporarily obscured by the Load Algorithm menu. The portion of the image that has been obscured is stored in the PC memory.

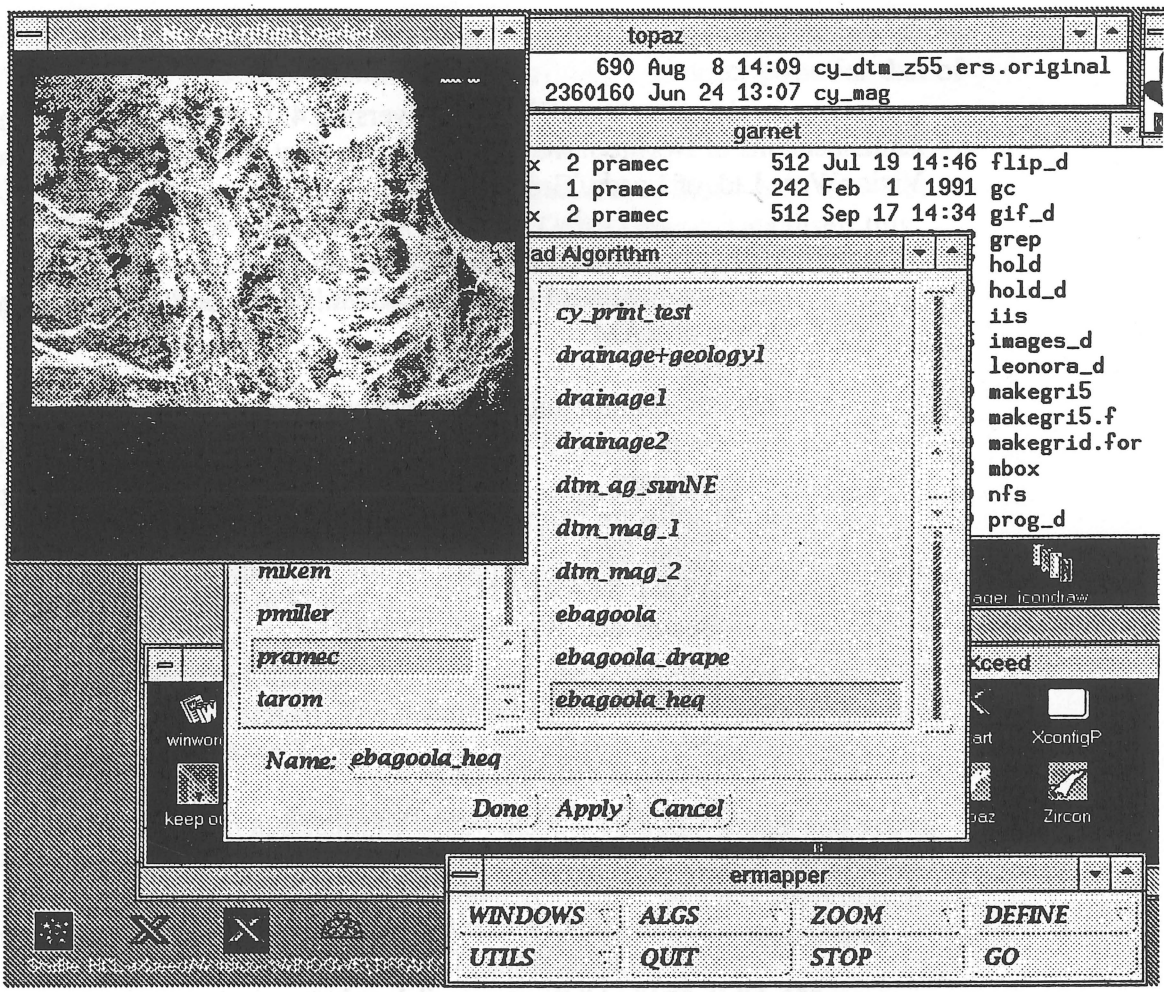

Figure 3 Clicking the mouse with the cursor in the image window restores the complete image to the screen. The portion of the image that had been obscured is written back to the screen by HCL-eXceed/W from the PC memory. In this way, the image is very quickly restored. This procedure is much faster than re-drawing the image over the ethernet from the remote host (which in this case is ZIRCON, a SUN 4/470).

XVision Configuration

An evaluation copy of XVision (version 4.0) was provided by Peripheral Enhancements of Northbourne Ave. Canberra City. This software is produced by VisionWare Ltd. of Leeds, Great Britain.

Minimum hardware and software requirements:

. an IBM-compatible PC with an 80286, 80386 or 80486 processor
. 2 Mbyte of RAM
. a hard disc
. a graphics monitor and display adapter supported by Microsoft Windows 3
. a 2 button mouse (a 3 button mouse is preferred) and software driver
. an ethernet card
. ethernet software from the following list:
    - 3Com TCP
    - AT&T STARLAN
    - Beame and Whiteside TCP/IP
    - FTP PC/TCP
    - HP ARPA Services
    - ICL OSLAN
    - Locus TCP/IP for DOS
    - Excelan & Novell Lan WorkPlace
    - SUN PC-NFS
    - Ungermann-Bass NET/ONE TCP-PC
    - Wollongong Path-Way
    - Wollongong WIN/TCP for DOS
. MS-DOS or PC-DOS version 3.1 or later
. Microsoft Windows version 3.0 or later

Installation of XVision was very easy. The software was installed from within Microsoft Windows 3 by running two different setup programs on the distribution discs. The first of these programs installed the VisionWare TCP/IP communications interface required for the TCP/IP package being used (in this case PC-NFS). The second setup program presented a list of available options (font resolutions, utilities, etc) and once the desired options had been selected, the program installed all the necessary files. A new program group was automatically created in Microsoft Windows and icons were generated within it for the main XVision programs (XVision, Program Starter and XVision Setup). A total of 5.27 Mbyte of hard disc space was required to install XVision.

Font aliasing was again required in order to satisfy ER Mapper version 2.0's need for the **d12lucida.snf** X font. The font aliasing procedure for XVision is much simpler than that for HCL-eXceed/W. All that is required in order to produce the alias is the creation of a file called FONTS.ALI in the appropriate font directory (in this case: \xvision\fonts\100dpi). The alias entry in this directory takes the form:

```
lucid   -B&H-Lucida-Bold-I-Normal-Sans-14-100-100-100-P-90-ISO8859-1
```

Note that the choice of the actual font to use as the alias for the required lucid font is up to the user. Any font could have been used by substituting its description for that of the one given in the example.

The FONTS.ALI file must be created and edited with an editor which does not insert a ^Z (i.e. CTRL-Z) at the end of the file. The XTGOLD editor does insert this character as an end of file marker and the result when XVision is run is a hung system which can only be freed by rebooting the computer. The Windows 3 Notepad editor is a suitable editor for FONTS.ALI.

XVision Performance

XVision is a stable X11 windows platform. The software is easy to use and relatively free from unexplained system crashes (all the emulators seem to suffer occasionally). XVision's reconfiguration ability from within Windows is a very useful feature. This feature is illustrated in Figure 4.

XVision was the fastest of the three X11 servers tested when it came to drawing both graphics and text to the PC screen. The results of the comparative tests of the three servers are given in Table 1 on page 7.

XVisions usefulness with applications which display complex image and vector datasets is however seriously limited by a major shortcoming in its screen management. Even with the maximum backing store setting ("when available" which is supposed to save all obscured windows irrespective of whether the X client requests this or not), graphics screens are not saved. This is illustrated in Figures 5 and 6.

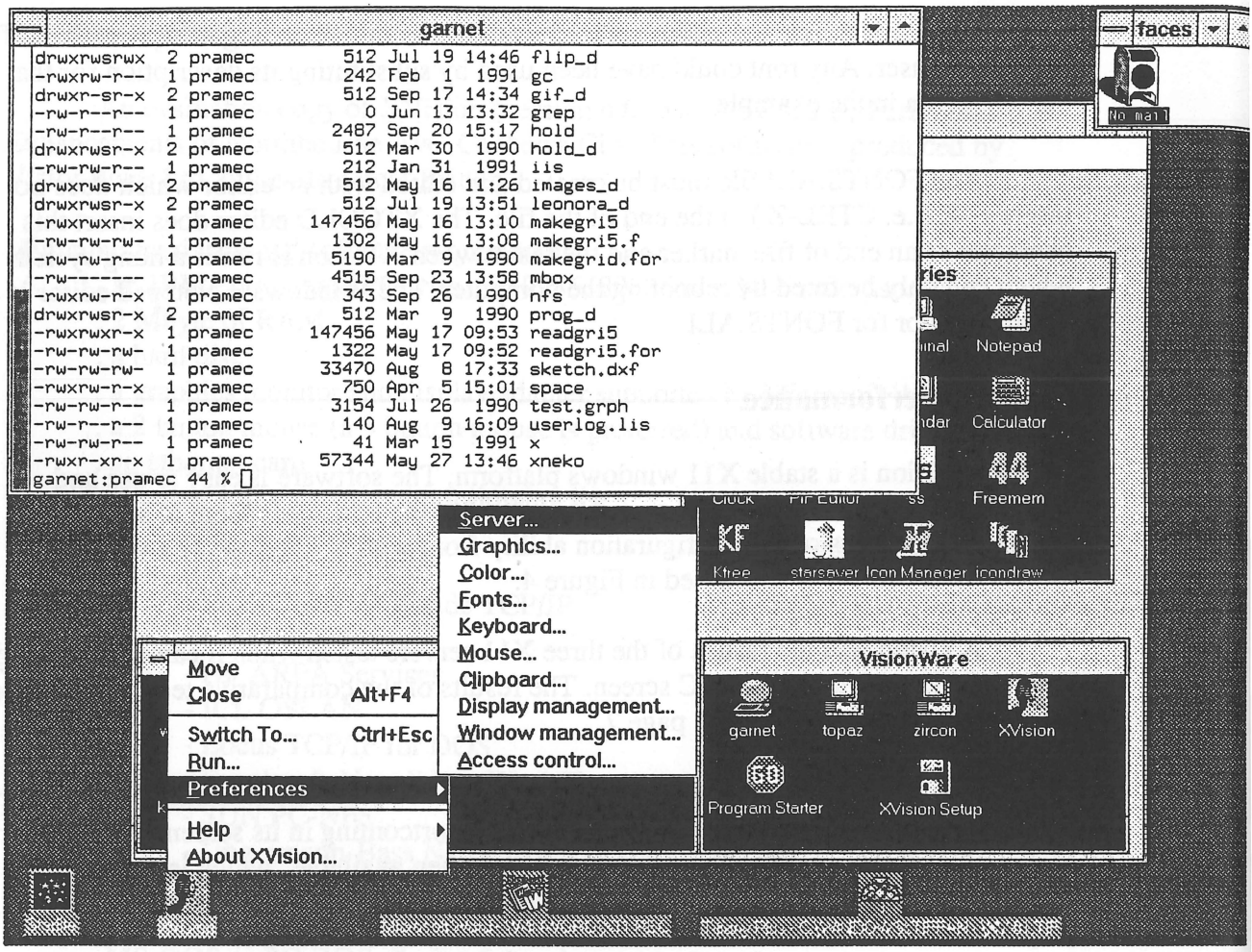

Figure 4 Xvision has a good re-configuration ability from within Microsoft Windows as shown here in the pop-up menus at the bottom of the screen. In some cases the X server must be re-started before these changes can take effect (which means that any existing UNIX sessions must first be closed) but overall the feature is very useful.

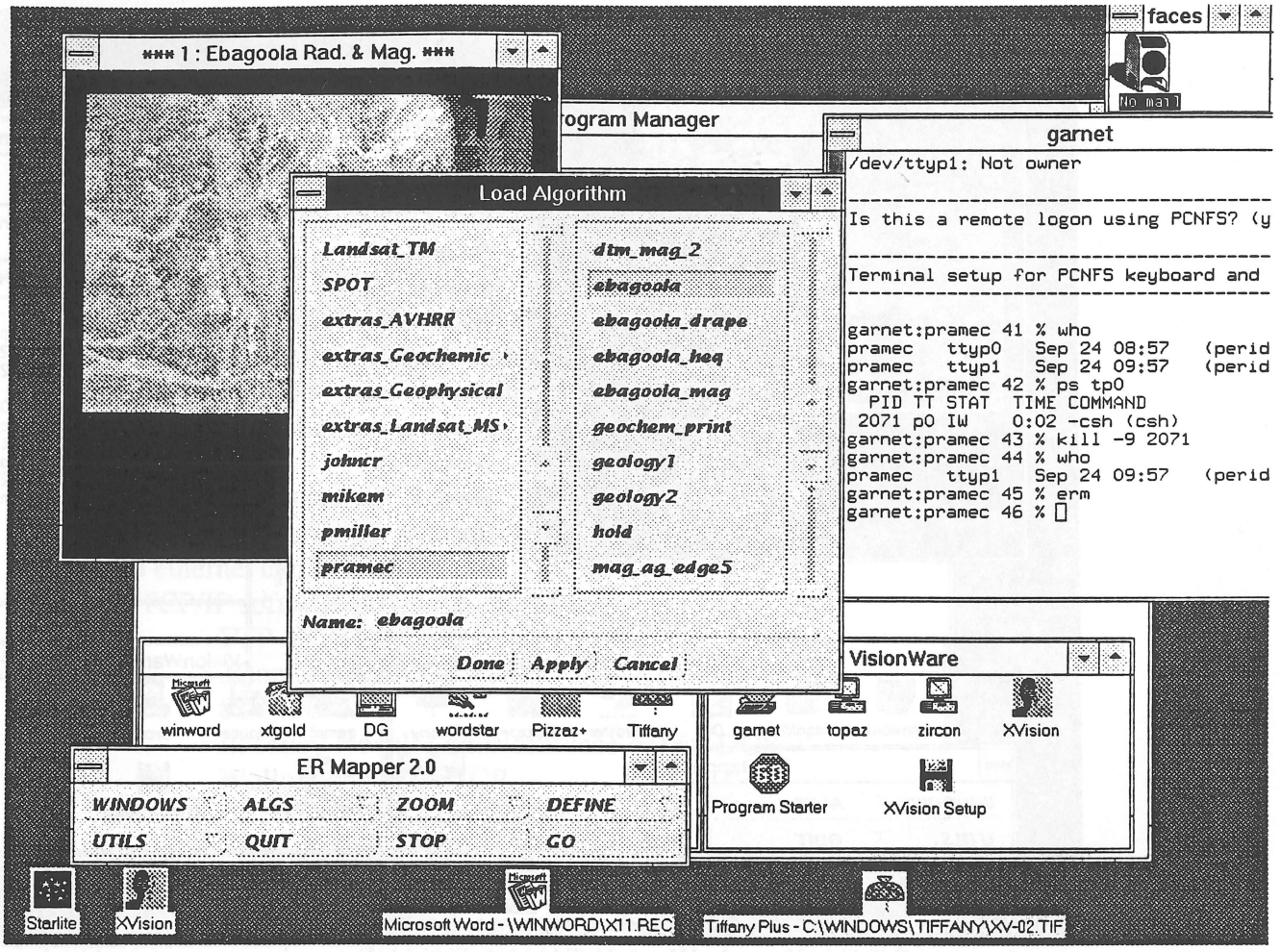

Figure 5 A captured screen from an XVision session on the GARNET SUN 4/280 file-server in which ER Mapper is being run. Note that the load algorithm menu screen is obscuring part of the image window.

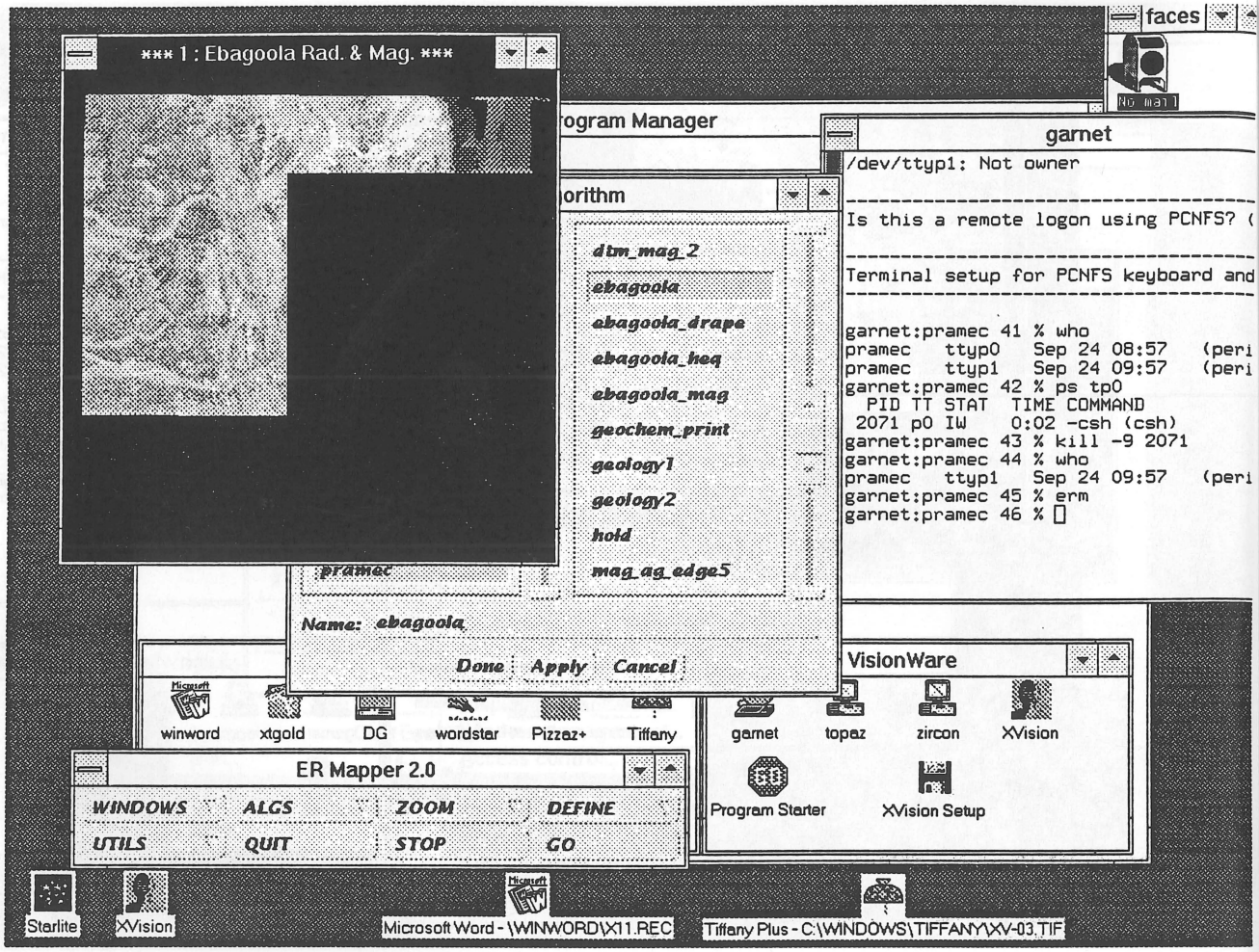

Figure 6 Clicking the left mouse button with the cursor within the image window brings the latter to the front. Note however that the portion of the image which had been covered by the load algorithm menu window (see Figure 5) is now lost.

Non-graphics windows such as the ER Mapper pop-up menu X windows are correctly saved and regenerated by XVision but these windows are much more quickly redrawn than graphics screens anyway (see the performance data in Table 1). The failure of XVision version 4.0 to correctly handle graphic screen "save-unders" makes it unworkable as a platform upon which to run graphics intensive applications such as ER Mapper and ArcInfo.

X11/AT Configuration

An evaluation copy of X11/AT (version 3.2.1) was provided by Select Computer Technology Pty Ltd of Mitchell, ACT. The software was produced by Integrated Inference Machines of Anaheim, California, USA.

Minimim hardware and software requirements:

. an IBM compatible PC with an 80286, 80386 or 80486 processor
. any graphics card which is supported by Microsoft Windows 3
. a colour monitor (required for image processing applications) or a monochrome monitor
. a hard disc
. Microsoft Windows 3
. a mouse (preferably 3 button)
. an ethernet card
. a TCP/IP software product from the following list:
- FTP PC/TCP
- 3Com 3+OPEN
- SUN PC-NFS
- Excelan/ Novell Lan WorkPlace 4.0 for DOS
- Wollongong WIN/TCP

Installing X11/AT is very straightforward. An easy to use program is provided which is run from within Microsoft Windows. This program (setup.exe) copies the necessary files to the hard disc and automatically builds the new X11/AT program group and adds the program icons (X11/AT, X11/AT Help, Wtelnet, X11/AT Setup and Wftpserv). The user installing the software only needs to indicate which of the supported TCP/IP transport packages is going to be used and which resolution of X font (75 dot per inch [dpi] or 100 dpi) is to be used, the installation then proceeds painlessly.

The configuration used to test X11/AT included 100 dpi X11 fonts. This configuration required 5.5 Mbyte of disc storage on the hard disc in addition to the 1.49 Mbyte required by PC-NFS.

Font aliasing uses a similar procedure to that used by XVision. Again a file called FONTS.ALI has to be added to one of the directories in the font search path. In order to create an alias for the **d12lucida.snf** font required by ER Mapper, the following entry is needed in a FONTS.ALI file:

lucid -b&h-lucida-bold-i-normal-sans-20-140-100-100-p-127-iso8859-1

Again, any other of the many X11 fonts provided by X11/AT could have been used rather that the example given here on the right hand side of the alias command.

X11/AT doesn't seem to be sensitive to a ^Z character at the end of the FONTS.ALI file in the same way that XVision is.

X11/AT Performance

The X11/AT server does not seem to be as robust as the other two X11 servers. The X11/AT server crashed inexplicably a number of times during testing. It also was not able to reliably display a full screen graphics image in ER Mapper. When a small image window was maximised (to full screen size) the ER Mapper main menu froze and as a result it was generally not possible to view images at full screen size. The only recourse when the main menu froze in this way was to kill ER Mapper (with a ^D) from the UNIX session in which it was run. A fairly drastic procedure.

X11/AT suffered from the same limitations that XVision was found to suffer from when it came to save-unders. The X11/AT server did not save image windows that were obscured by other windows or by menus (see Figures 7 and 8) irrespective of the save-under configuration selected. It also did not restore image windows that had been minimised (to an icon). The restored window was always empty and had to be redrawn (slowly) by the remote cpu over the network.

Of the three X11 servers tested, X11/AT was the slowest to draw both graphics and text screens (see Table 1 on page 7). This slowness when coupled with X11/AT's inability to correctly perform save-unders for image windows makes it a poor platform upon which to run UNIX applications such as ER Mapper and ArcInfo.

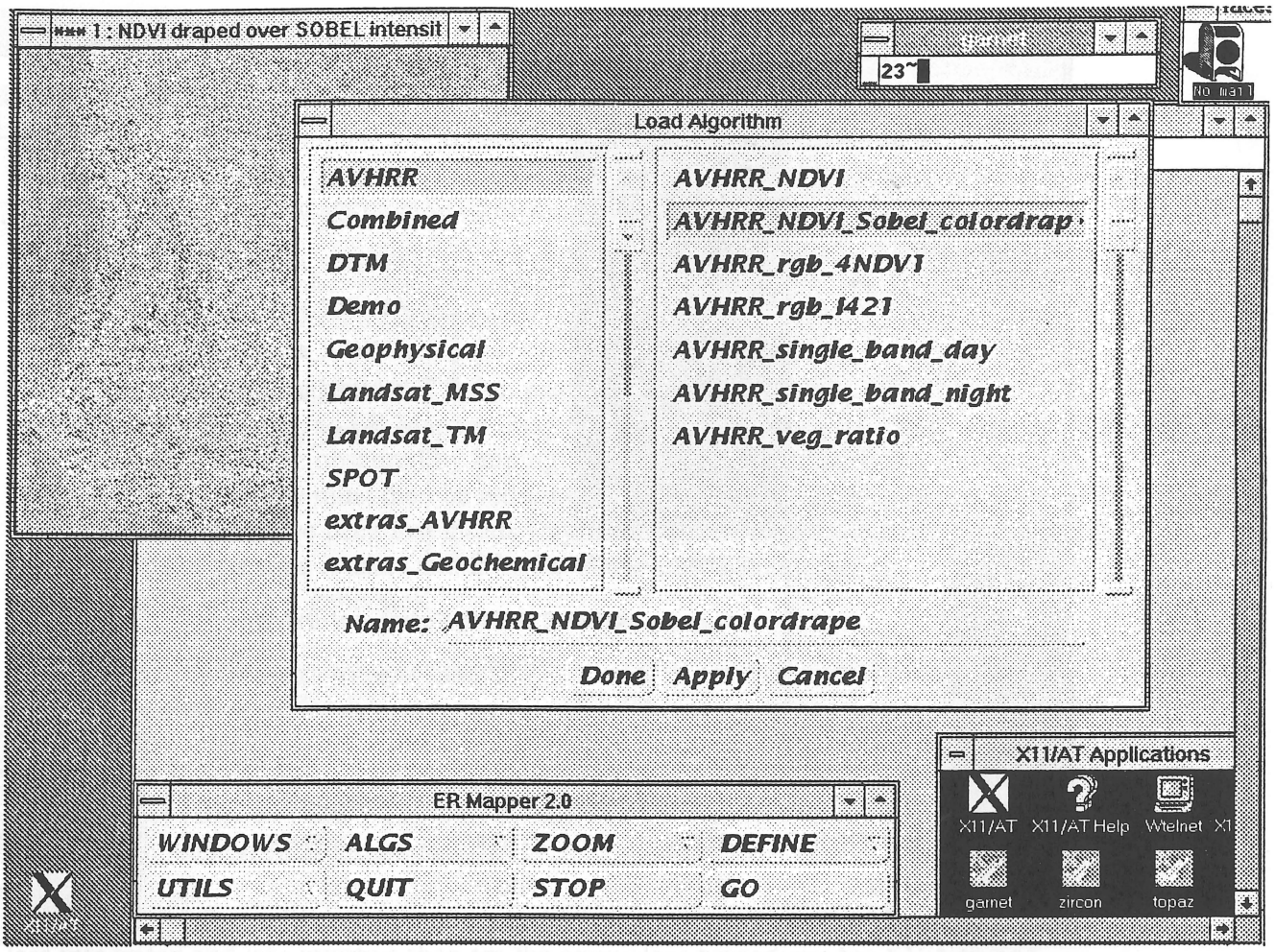

Figure 7 A screen captured during an X11 session with X11/AT and the ER-Mapper image processing software. Note that the Load Algorithm pop-up menu is obscuring part of the image window.

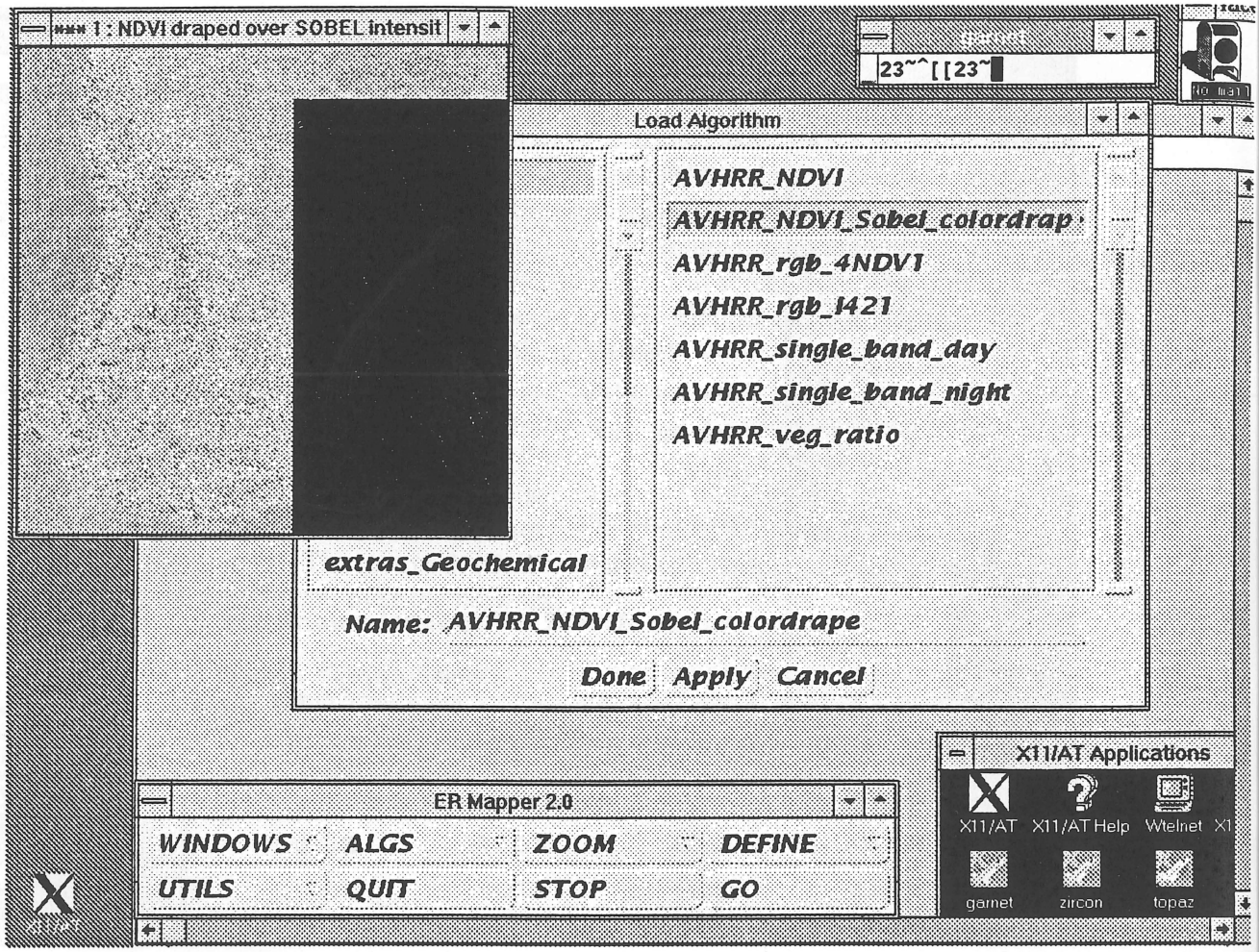

Figure 8 Another screen captured during the session with X11/AT and ER-Mapper. Note that when the image window is brought in front of the previously obscuring pop-up menu, the image is incomplete. The bottom right corner of this rectangular image is missing.

Conclusions

Of the three X11 servers tested, one stands out as being best for BMR's applications. This product, HCL-eXceed/W provides the kind of save-under and restore-from-icon functionality that is needed in order to painlessly run UNIX applications such as ER Mapper (and ArcInfo version 6) on remote PC workstations. HCL-eXceed/W is not as fast at screen drawing operations as XVision though this may, at least in part, be due to the higher overheads it has in correctly performing save-unders. HCL-eXceed/W does however draw its screens faster than the other product, X11/AT.

Both XVision and X11/AT fail to provide proper local screen management of graphics windows (such as ER Mapper images). In both cases, the content of graphics windows which become obscured by impinging menus and other windows are lost. The entire obscured window must then be redrawn by the remote UNIX host in order to restore the data that have been lost in this way. This redraw imposes a substantial penalty both in terms of the time it takes and in terms of the substantial unnecessary ethernet network traffic which it generates.

The installation procedures for HCL-eXceed/W are considerably more complicated than those for XVision and X11/AT. This is partly because HCL-eXceed/W is a more powerful package with a more extensive range of configuration options. It is also a result of the lack of an integrated Microsoft Windows compatible installation procedure for HCL-eXceed/W. Hopefully this will be improved in future releases of the product (the version examined was 1.0).

The configuration (and reconfiguration) procedures for HCL-eXceed/W are also less integrated and less intuitive than are the equivalent procedures for XVision and X11/AT. The configuration program for HCL-eXceed/W, called XconfigP, is an MS-DOS application and, though it can be run from a DOS icon within Microsoft Windows, it doesn't support a mouse and it doesn't have a standard Windows type interface. This should also be improved in future releases of HCL-eXceed/W.

Because the installation and configuration of HCL-eXceed/W are somewhat complicated, prospective users and particularly novices to Windows 3, X11 and TCP/IP, may find it difficult to correctly install the product. For this reason, a comprehensive installation guide has been provided for BMR users (Chopra, 1991b).

Recommended Hardware and Software Configurations

HCL-eXceed/W has been successfully run on two different computers:

- an 80386 Osborne PC with an 80387 co-processor, 8 Mbyte of RAM, a Tseng Labs MegaEva/1024 super VGA card, a NEC 5D 19 inch multisynch monitor, a 3C503 ethernet card and a Logitech 3 button bus mouse.

- an 80486 Osborne PC, with 4 Mbyte of RAM, a Tseng Labs MegaEva/1024 super VGA card, a NEC 3D 14 inch multisynch monitor, a 3C503 ethernet card and a Microsoft 2 button serial mouse.

Each of these computers used MS-DOS 4.01 as the operating system, Microsoft Windows 3.0 as the local window manager and PC-NFS version 3.01 as the TCP/IP network software.

Experience with these computers and consideration of the minimum hardware and software requirements for HCL-eXceed/W (see page 6) suggest that a good PC X11 workstation using HCL-eXceed/W would need to at least reach the following standard:

- an 80386 PC with 4 MByte of RAM
- a super VGA (or 8514A or XGA) graphics adapter capable of driving a screen size of 1024 by 768 with 8 bits per pixel (i.e. 256 colours) in Microsoft Windows 3 (i.e. a Windows 3 screen driver for this resolution **must** be available)
- a multisynch monitor with sufficient bandwidth to display the output of the graphics adapter
- a 3 button serial mouse with a Windows 3 driver which supports all 3 buttons (e.g. a Logitech mouse and the Logitech Plus driver)
- a 3C503 ethernet card
- a hard disc with at least 6.2 MByte of disc space
- MS-DOS 4.01
- Microsoft Windows 3.0
- TCP/IP software from the list on page 6

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Hassey M., (1991). DOS-to-UNIX connectivity, part II, *UNIX Review*, 9, 62-64.

Mikes S. (1990). 3 X window servers for DOS, *UNIX World*, November 1990, p113-118.

Powell M., Boldt D. and Negri M. (1991). X display servers for the PC, *US Geological Survey, Information Systems Developments*, 8, 153-161.

Appendix A HCL-eXceed/W server specifications

```
garnet:pramec 60 % xdpyinfo -display peridot:0
name of display:    peridot:0.0
version number:    11.0
vendor string:    Hummingbird Communications Ltd.
vendor release number:    0
maximum request size:  4096 longwords (16384 bytes)
motion buffer size:  1
bitmap unit, bit order, padding:    8, MSBFirst, 16
image byte order:    MSBFirst
number of supported pixmap formats:    2
supported pixmap formats:
    depth 1, bits_per_pixel 1, scanline_pad 16
    depth 8, bits_per_pixel 8, scanline_pad 32
keycode range:    minimum 8, maximum 109
number of extensions:    2
    HCL-DOS-Access
    SHAPE
default screen number:    0
number of screens:    1

screen #0:
  dimensions:    1024x768 pixels (240x180 millimeters)
  resolution:    108x108 dots per inch
  depths (2):    1, 8
  root window id:    0x8006a
  depth of root window:    8 planes
  number of colormaps:    minimum 1, maximum 1
  default colormap:    0x80065
  default number of colormap cells:    256
  preallocated pixels:    black 0, white 255
  options:    backing-store YES, save-unders NO
  current input event mask:    0x1c0000
    ResizeRedirectMask    SubstructureNotifyMask    SubstructureRedirectMask
  number of visuals:    1
  default visual id:  0x80064
  visual:
    visual id:    0x80064
    class:    PseudoColor
    depth:    8 planes
    size of colormap:    256 entries
    red, green, blue masks:    0x0, 0x0, 0x0
    significant bits in color specification:    8 bits
```

Appendix B XVision Server Specifications

```
topaz:pramec 44 % xdpyinfo peridot:0
usage: xdpyinfo [-display displayname]
topaz:pramec 45 % xdpyinfo -display peridot:0
name of display:    peridot:0.0
version number:    11.0
vendor string:    VisionWare Limited
vendor release number:    4
maximum request size:  4096 longwords (16384 bytes)
motion buffer size:  0
bitmap unit, bit order, padding:    32, LSBFirst, 32
image byte order:    LSBFirst
number of supported pixmap formats:    2
supported pixmap formats:
    depth 1, bits_per_pixel 1, scanline_pad 32
    depth 8, bits_per_pixel 8, scanline_pad 32
keycode range:    minimum 1, maximum 254
number of extensions:    2
    SHAPE
    MIT-SUNDRY-NONSTANDARD
default screen number:    0
number of screens:    1

screen #0:
  dimensions:    1024x768 pixels (216x162 millimeters)
  resolution:    120x120 dots per inch
  depths (2):    1, 8
  root window id:    0x8006c
  depth of root window:    8 planes
  number of colormaps:    minimum 1, maximum 1
  default colormap:    0x8006a
  default number of colormap cells:    256
  preallocated pixels:    black 0, white 255
  options:    backing-store YES, save-unders YES
  current input event mask:    0x100000
    SubstructureRedirectMask
  number of visuals:    6
  default visual id:  0x80064
  visual:
    visual id:    0x80064
    class:    PseudoColor
    depth:    8 planes
    size of colormap:    256 entries
    red, green, blue masks:    0x0, 0x0, 0x0
    significant bits in color specification:    8 bits
  visual:
    visual id:    0x80065
    class:    DirectColor
```

```
  depth:  8 planes
  size of colormap:  8 entries
  red, green, blue masks:  0x7, 0x38, 0xc0
  significant bits in color specification:  8 bits
visual:
  visual id:  0x80066
  class:  GrayScale
  depth:  8 planes
  size of colormap:  256 entries
  red, green, blue masks:  0x0, 0x0, 0x0
  significant bits in color specification:  8 bits
visual:
  visual id:  0x80067
  class:  StaticGray
  depth:  8 planes
  size of colormap:  256 entries
  red, green, blue masks:  0x0, 0x0, 0x0
  significant bits in color specification:  8 bits
visual:
  visual id:  0x80068
  class:  StaticColor
  depth:  8 planes
  size of colormap:  256 entries
  red, green, blue masks:  0x7, 0x38, 0xc0
  significant bits in color specification:  8 bits
visual:
  visual id:  0x80069
  class:  TrueColor
  depth:  8 planes
  size of colormap:  8 entries
  red, green, blue masks:  0x7, 0x38, 0xc0
  significant bits in color specification:  8 bits
topaz:pramec 46 %
```

Appendix C X11-AT Server Specifications

```
garnet:pramec 41 % xdpyinfo -display peridot:0
name of display:    peridot:0.0
version number:    11.0
vendor string:    Integrated Inference Machines
vendor release number:    30201060
maximum request size:  4095 longwords (16380 bytes)
motion buffer size:  0
bitmap unit, bit order, padding:    8, MSBFirst, 16
image byte order:    MSBFirst
number of supported pixmap formats:    2
supported pixmap formats:
    depth 1, bits_per_pixel 1, scanline_pad 16
    depth 8, bits_per_pixel 8, scanline_pad 8
keycode range:    minimum 8, maximum 255
number of extensions:    0
default screen number:    0
number of screens:    1

screen #0:
  dimensions:    1024x768 pixels (240x180 millimeters)
  resolution:    108x108 dots per inch
  depths (2):    8, 1
  root window id:    0x80071
  depth of root window:    8 planes
  number of colormaps:    minimum 1, maximum 1
  default colormap:    0x8006a
  default number of colormap cells:    256
  preallocated pixels:    black 0, white 255
  options:    backing-store YES, save-unders YES
  current input event mask:    0xd00000
    SubstructureRedirectMask PropertyChangeMask      ColormapChangeMask
  number of visuals:    6
  default visual id:  0x80064
  visual:
    visual id:    0x80064
    class:    PseudoColor
    depth:    8 planes
    size of colormap:    256 entries
    red, green, blue masks:    0x0, 0x0, 0x0
    significant bits in color specification:    8 bits
  visual:
    visual id:    0x80065
    class:    StaticColor
    depth:    8 planes
    size of colormap:    256 entries
    red, green, blue masks:    0x0, 0x0, 0x0
    significant bits in color specification:    8 bits
```

```
 visual:
  visual id:  0x80066
  class:  DirectColor
  depth:  8 planes
  size of colormap:  8 entries
  red, green, blue masks:  0x7, 0x18, 0xe0
  significant bits in color specification:  8 bits
 visual:
  visual id:  0x80067
  class:  TrueColor
  depth:  8 planes
  size of colormap:  8 entries
  red, green, blue masks:  0x7, 0x18, 0xe0
  significant bits in color specification:  8 bits
 visual:
  visual id:  0x80068
  class:  GrayScale
  depth:  8 planes
  size of colormap:  256 entries
  red, green, blue masks:  0x0, 0x0, 0x0
  significant bits in color specification:  8 bits
 visual:
  visual id:  0x80069
  class:  StaticGray
  depth:  8 planes
  size of colormap:  256 entries
  red, green, blue masks:  0x0, 0x0, 0x0
  significant bits in color specification:  8 bits
garnet:pramec 42 %
```