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I.

Getting Started

A. WHAT YOU NEED

If you are new to Open Windows and graphical user interfaces, read the first two chapters describing the consistent elements such as windows, popups, mouse control, menus, and the keyboard layout. These sections will also briefly describe some of the programs you will find useful in the Open Windows system. For a more detailed overview of SUN workstations and Open Windows, please refer to the workstation manuals provided by SUN.

If you have used Open Windows before, but are new to the Rational Imaging system, skim the first two chapters to get the basics of the user interface. Then read chapter 3 for an overview of the image display environment and Rational Imaging's specialized approach to filmless imaging. Finally, concentrate on chapters 4 through the end of the manual. Or you may read individual chapters as your needs require.

If you are already familiar with a previous version of Rational Imaging, proceed to those sections describing the upgrades and advanced imaging techniques.

B. TYPOGRAPHICAL CONVENTIONS

In this manual, the names of the keyboard keys are printed in boldface and enclosed brackets <>, such as <Enter>, <Tab>, <F1>, and so on.

Text that you type appears in boldface, such as password.

Sub menu items that you choose from pull-out menus follow the convention: menu name | option | sub-option. For example, to print the current page from the print popup in RI'view, you will select the "current" instruction from the menu under the "print" button. This manual will display this option as print | current.

The illustrations in this manual demonstrate the user interface and the imaging environment. As you become familiar with the versatility of these programs, you will develop your own approach to image processing and customize your environment accordingly.

C. RATIONAL IMAGING WORKSTATIONS

The Rational Imaging system is comprised of a group of programs designed to meet all of your clinical requirements. One application may import the digital images while others are used for examining the images on the monitor, annotating selected images for exam documentation, or archiving the exam on high capacity tapes. Since the Rational Imaging system operates under Open Windows on a UNIX based operating system, each program can be run independently (multi-
tasking) so that you can continue working while the computer is busy printing, importing or archiving. This flexibility also allows you to view several exams side by side for comparison of MR and CT images or for evaluating the progression of disease. These individual applications will be discussed in detail in the subsequent chapters.

The SUN workstations provide the UNIX operating system, an X compliant graphics server (Open Windows or Motif), and the TCP/IP network protocols required for workstation and image communication. Even a standalone workstation requires a network to allow images to be imported into the image database. When upgrading the network components of the system, consult with your system's administrator to make sure that the addresses are assigned properly. Additional information regarding network upgrades can be found in SUN's network manager's guide and the administrator's guide provided with this software.

The **Rational Imaging** installation manual will describe the procedures necessary to add users, add additional printers or scanners, and modify other system configurations. The current system requirements and installation instructions are also outlined in this manual. **DO NOT reinstall the system without first contacting the technical support hotline distributed with this software package. Doing so will compromise the integrity of the patient archives (backup tapes) and will VOID the warranty.**

**D. GETTING HELP**

Each application has built-in context sensitive help. If you have a question as to the operation of a particular item on the graphical interface, simply position the cursor over that icon and press the Help key in the upper left corner of the keyboard. A window will then appear giving operational details regarding the item. The user's manual can also be setup to be available on the desktop using PostScript viewers supported on Sun Workstations.

If you wish to report a problem, please include your name, your position, the name of your facility, your fax and phone numbers, the Software ID number (found on the system disks and on the technical support card) and a description of the problem. Please be as specific as possible in defining the symptoms of the problem. A logbook has been provided for your convenience to help you record this information and track system performance. Please pay close attention to the instructions in the book and fill everything out completely. This will allow technical support to quickly identify problems and potentially circumvent future problems that may arise.

**E. QUICK START**

Use the following instructions to initialize the **Rational Imaging** system. If you are currently logged into another system on the workstation, log out of the workstation first. To log out of the graphical Open Windows environment, use the right mouse button over the background...
Chapter 1. Getting Started

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I-3

(workspace) of the screen to display the workspace menu. Then select exit from this menu (workspace menu | exit | confirm). If you were not in OpenWindows, type logout or exit at the UNIX command prompt.

At the login: prompt, enter your username. Use upper and lower case exactly as you created the user. It is recommended to only use lower case characters for user names for this reason.

Enter your password at the password: prompt. You will not see the password characters for security reasons. If you make a mistake, the system will reject your login and will again prompt you with login:.

If the installation and user information was entered correctly, the system will begin initializing OpenWindows and the RI system environment. The UNIX console should appear in the lower left corner of the screen. If there are no RI programs present as icons (at the bottom of the screen), they can be selected from the program launcher RI'login by selecting imaging from the workspace menu (workspace menu | imaging). If the RI'login program is running as an icon at the bottom of the workspace, simply double click over its icon to activate it.

Once RI'login is running, select the desired program from the graphical interface by clicking over its icon once with the left mouse button. The following section describes RI'login in detail.

F. RI'LOGIN - PROGRAM LAUNCHER

The RI'login program is used to run all of the other programs in the Rational Imaging system. This program, whose icon is shown at right, will usually run in the upper right portion of the screen or as an icon located at the bottom of the screen. It uses very little memory, so it does not have to be quit like the other applications. RI'login is used to control the operation of the other Rational Imaging applications, and to allow users to log in and out without having to exit the Open Windows system. After logging in using the login button, each program you run will be linked to your user name. This is very important since some of the programs link your username with functions performed by the system. For example: the display package "riview" uses your username to record who reviewed, dictated, or archived a particular exam. This system maintains security and provides accountability if used properly. It is up to you to enforce these security measures by using the login and logout functions.

The RI'login user interface is shown above. The functions available to the user are described in the following sections.

Login

The login button opens the login window. Simply click in the Username field to make it active, and enter your username. Press the <tab> key to accept your username and proceed to the Password prompt. Enter your password followed by <enter>. If your password is accepted, then "Password OK" will appear and a menu of databases that you have access to will appear in the database field. Select the database you desire using the right mouse button (there may only be one), and then click on accept. Unless you require extra security by using separate databases for each department, it is recommended to use one database for the entire imaging system. This will give the users the easiest access to their...
images and simplify the import and archiving protocols for the network. Discuss this issue with your system administrator and our technical representatives.

If these operations are performed correctly, then your name will appear at the top border of the RI'login window. If this border shows *Rational Imaging*, then you will need to log in again. If successive attempts fail, then contact your system administrator to verify that your username exists in the UNIX system and in the database table "users". See the installation manual for more information on creating users.

Since many functions throughout the database are linked to your username, it is highly recommended that you login and logout properly. When the *Rational Imaging* system is initialized by logging in at the UNIX login prompt, it is usually operating under a guest account, such as *imaging*. This way the technologists can easily use the system without having to log out of the Open Windows environment to change users. **When a physician uses RI'login, they simply login and use the desired applications. When they complete their review, they should quit their applications and select logout.** NOTE: Changing the login name under RI’login does not effect applications currently running. Therefore, always log in before running any applications.

If RI'login is run from the Workspace menu, the system assumes that the Open Windows user has already logged in at the UNIX prompt, and this user is automatically logged in. Therefore, if a workstation is used by many people, it is recommended not to log in to the UNIX prompt as high security personnel, otherwise the rilogin program run from the workspace menu will be linked to their username.

**Save Configuration**

This button will allow you to change and save various program defaults. For example, if you want the system to notify you whenever you run a program remotely, then set Host Warning to Yes. You can also verify the current user each time a program is run by setting the User Warning to Yes. RI'login will also check and update the disk space values automatically by setting the number of minutes in this field. The default is 5 minutes. This way if *riport* is importing images in the background, the disk space shown by RI’login will be close to their actual values. To obtain an accurate measure of disk space on any host, simply select the host under the "Run on host:" option. This will update the disk space value for the selected host.

The text window at the top of this popup allows you to type in the order of the programs you want to be displayed as icons in the program popup. Enter the exact name of the Rational Imaging program followed by a carriage return for each of the programs desired.

When you click on the *save defaults* button, then these options along with the current locations of each of the windows and popups will be saved to the disk file ".rilogin4" in the
user’s default directory. The next time RI'login is run, the windows associated with RI’login will return to their present locations with these options set. The program names are saved in the .rilogin_P file in the user’s defaults directory, or in the /home/ist/bin directory if you wish to override the user defaults and customize a particular workstation. For example, if a workstation is used primarily by physicians, then they may wish to simplify the program menu so that only RIview is present. If a version of .rilogin_P is found in /home/ist/bin, it will take precedence over any values found in user’s defaults directories.

**Print tool**

This button launches the UNIX printtool provided as part of the SUN operating system. This will allow you to check the status of various print jobs and add or remove files from the print queue. This program will not operate if there are no printers installed. See SUN's deskset manuals for more information regarding the printtool application.

**Lock Screen**

The lock screen feature allows you to lock the screen to prevent unauthorized access. This is faster than logging out of the Open Windows system and having to log back in again. *This is especially useful when you are performing archives at night and do not want the cleaning staff or other unauthorized personnel accessing the system.* To unlock the screen, simply press enter and then enter your password at the Password prompt followed by <enter>.

**Information**

This button will display program information pertinent to the RI'login program. Use this button to find the version number when reporting errors.

**Logout**

This button will log you out from the Rational Imaging system. This will prevent other users from running programs using your username and performing functions which will be linked to your name. It is recommended practice to logout or lock the screen whenever you leave the workstation. **Remember to quit all programs which were linked to your username (especially riview).**

**Hide/Show Icons**

This button will display the program popup with the available applications. This button will toggle the presence/absence of this popup, and will change from hide to show accordingly. The order of the applications in the program popup is entered in the configuration popup for RI’login.

**Run on Host**

This function allows you to choose one of the other RI workstations to operate a particular program. Since the program interface will be slower over the network, this is only recommended for the *riport* or *ristore* applications since they need to access remote disk and tape drives. If your current disk becomes full, you may need to run *riport* on another workstation to import images to that system. You could easily go to that workstation to perform the import, however this function lets you operate the program remotely. You could also run *ristore*
remotely if your archive tape drive is attached to a system other than the one you are currently at.

When you select a RI workstation, the disk space on that workstation appears in the Disk Space field. Any program run after specifying the "run on host:" will actually be run remotely on that host. You must have appropriate privileges assigned by UNIX to operate programs remotely. See the installation guide or the SUN network manager's guide to set these permissions correctly.

**System Statistics**

The system statistics for the selected workstation is shown as colored gauges to reflect the amount of a particular system resource available. The canvas will appear green if the current level is acceptable. The canvas will turn yellow to warn the user of low resource levels. And the canvas will turn red to reflect critical levels.

**Program Popup**

The standard applications provided with the Rational Imaging system are shown as icons in the program popup associated with RI'login. These programs can be operated from RI'login by clicking on the icon once with the left mouse button. The operator will be notified if the application is already running.

You must be logged in prior to running an application. The RI'login program will not launch a program until a valid login has been performed. When an application is run, it will notify the user if the program is already running. Sometimes multiple programs are desired to import from multiple scanners or to view several exams at a time. However, each of these programs takes considerable memory and database resources, so try to keep them to a minimum. **Always remember to quit each application when you are through with it.** This will release system resources and prevent anyone else from using the program which is linked to your username.

The following is a list of the *Rational Imaging* applications which provide the operations fundamental to filmless radiology:

- **rilogin** Rational Imaging program launcher
- **riport** Image import/export
- **riview** Image review and printing
- **ristore** Image archiving and retrieval
- **rimove** Remove images from the database (*use cautiously*)

Each of these applications begins with "ri" (pronounced "re"), and ends with a functional description. This allows the user to easily determine which programs are part of the Rational Imaging system and which were provided by the UNIX operating system. Any RI programs added to the system as upgrades, will appear on the RI'login interface and allow you to run them by simply clicking over the program's icon once with the left mouse button.

This information should be sufficient for you to load the *Rational Imaging* system and begin using the applications. Proceed with the following chapters to become familiar with the
imaging environment and each of the programs incorporated in the *Rational Imaging* system.

### G. Help Text

Help text is available over any button or component of the application’s interface by pressing the “Help” key on your keyboard. Simply position the mouse cursor over the item you have a question about and press the help key. When you are done reading the help text, click on the push-pin in the upper left corner to close the help popup. This on-line help allows you to query specific functions and learn more about the Rational Imaging system while using it.

### H. Open Windows Console

The console is used to enter UNIX commands and run various software applications. It is also used to report any error messages which may occur during your Open Windows session. Usually, the console is located in the lower left corner of the screen and has the icon shown at right.

When the console is opened, you will see a UNIX prompt for the currently logged in user. The user specified in this window is the one who initially logged into Open Windows. Be careful that you do not exit and quit the console, as this window is used by the system to report any errors and system problems. If the console should be quit accidentally, simply restart it by selecting it from the utilities menu “workspace menu | utilities | console”.

Whenever you encounter a problem, record the program’s error message(s) in the *RI log book*. Then open the console by double clicking over the icon with the left mouse button. Record any system error messages present in the console before calling your system administrator or Technical Support. This information will allow our technical support to determine the nature of your problem quickly and efficiently.
II. Finding Your Way Around

A. STARTING AND EXITING

Login

To login to the RI system, first turn on the monitor and make sure that you see the login: prompt. If the screen appears blank even though the monitor's power is on, press <enter> to disable the screen blanking program. This program blanks the screen after 10 minutes of inactivity to retain the life of the monitor and prevent phosphor burn-in.

Type your username at the login: prompt followed by <enter>.

Type your password at the password: prompt followed by <enter>. The password will not be displayed for security reasons.

If these values were entered incorrectly, you will be notified and again prompted with login:. If your username and password were authorized properly by the system, then system initialization will commence. A login script will load your personal configuration and open the RI system environment. When fully initialized, the workspace, also known as the screen, will display a colored background with several icons at the bottom of the workspace. The main console icon and the Rational Imaging program launcher's icon will appear in the lower left corner of the workspace. Unless the startup environment is changed using the save workspace command (workspace menu | utilities | save workspace), the system will always be initialized in this fashion. Additional details regarding the save workspace function are given under the Rational Imaging Program Components (page II-5).

Logout

Be careful when you exit from the Open Windows environment. Make sure that all import/export procedures using RI'port have completed. Also make sure that the tape is not in the process of archiving. Open each of the icons and quit them using the Quit button on their main windows. If they are already open, simply click on the Quit button.

To exit from the Open Windows environment, select Exit... from the workspace menu (workspace menu | Exit... | confirm YES). To display the workspace menu, simply click quickly on the right mouse button while the cursor is over a blank portion of the workspace. If the cursor is
over an icon or another program, then various other menus will appear. If the right mouse button (menu button) is pressed quickly, then the menu will remain on the screen. With the menu present, click with the right mouse button again over the "Exit..." command. You will be prompted to confirm your selection to exit from Open Windows. Click on Exit with the left mouse button to quit Open Windows and log out. Click on cancel to stop the request.

Logging out merely relinquishes the computer console for another user, and does not shut off the system. You may shut off the monitor at this point, however do not shut off the computer power or database integrity will be compromised. See the section on system shutdown in the installation manual to turn off the system power.

In addition to logging in and out at the UNIX login prompt, you can also log in using the RI'login application (Rational Imaging program launcher). This program allows easy access to your user environment without having to log completely out from Open Windows. Remember to click on the logout button so that other users will not be accessing the system under your user account.

**Recommended Practice**

The SUN SparcStation has been designed to remain on at all times. In fact, there is more wear on the system and disk drives if they are turned on and off each day. Additionally, the RI system will be networked in such a way that each of the systems is dependent upon the other. If one of them is shutdown without warning, the integrity of the system will be compromised. Therefore, unless service is required, leave the computer system, disk drives, tape drives, and any modems on at all times.

It is recommended to shut off the monitor when not in use. This will cool the unit and retain the life of the display tube.

Tape drives, film scanners, and printers may also be shut off when not in use. **Warning, SCSI devices must be terminated externally with active terminators to allow them to be shut off.** If they are terminated internally with the system power, then when the power is shut off, the scsi bus will become unterminated and hard disk malfunction will likely occur. If you have any questions regarding these issues, consult our technical support staff.

The canon printer may be shutdown during periods of non-use, provided that no one will be accessing the device from another networked facility. Remember, these network devices may be accessed from far and wide depending upon the layout of your facility and departmental requirements. At a minimum, select the stand-by feature of the Canon PFI printer when not in use to minimize heat and wear on the printer components.

When not using the system, logout to prevent unauthorized access. Since your username is linked to patient database flags such as archival, image preparation, image review, printing, and dictation, it is recommended that you do not leave the system without logging off or locking the screen. In a multi-workstation system, it will be useful however, to leave one of the workstations logged in by the "Technologist" or "Guest" if it is not important which technologist prepared or archived an exam. This will make it easier to leave one system operating during image archiving and import/export. **When leaving this workstation unattended, lock the screen so that unauthorized personnel will be denied access.**

If this system is to perform archival during the night, it will need to remain on and logged in. Locking the screen allows these functions to be performed without giving access to confidential patient records by unauthorized night staff.
Shutdown System for Maintenance or Moving

**DO NOT** simply shut off the power for system maintenance or to move the workstation. Multi-tasking UNIX workstations require that you follow a specific procedure to shutdown the operating system. It is especially important in a networked environment where interdependence exists between all of the workstations. Follow the shutdown instructions given in the installation manual, otherwise disk integrity may be compromised.

Always archive ALL of the patients on the *RI* system before halting the database server. This will minimize the loss of data should a disk malfunction occur during system startup. Coordinate this effort with our technical support staff to prevent loss of data.

B. **THE RATIONAL IMAGING SCREEN**

The following sections describe the components of the graphical user interface. This interface consists of a uniform set of operational features based upon the Open Windows specifications. This chapter is dedicated to describing and making you familiar with the operational components of the system. The **Rational Imaging** system is comprised of a custom set of software applications to perform image display, processing, printing, network distribution and archival. Subsequent chapters will describe these applications in detail.

The Workspace

The workspace is defined as the colored screen upon which programs, icons, and menus may appear. The philosophy behind this workspace is analogous to that of a "desktop". Keep it tidy with only those programs on the surface that are used often. Programs used rarely can be conveniently hidden in the workspace menu or accessed by typing commands at the main console. When a program is desired, simply open it from one of the icons on the program launcher *RI*’login. When not using a program, quit the program to release the memory used by the program. The only exception to this is with the program launcher, since *RI*’login uses very little memory and controls the operation of all of the other applications. If you wish to minimize the screen space that *RI*’login uses, simply click on the control triangle in the upper left corner to iconify the program. To maximize or open it again, simply double click on its **Rational Imaging** icon at the bottom of the workspace.
Always make sure to "close" a patient exam when you are done with it. This will allow other users to access the exam and relinquish the memory that was used for the images.

The workspace is initialized during login, however during normal use it will become filled with programs, images, icons and windows associated with the image display. At some point, it may become necessary to reinitialize the workspace to return it to its standard form. This can be accomplished easily by logging off and logging back in. Proceed cautiously however, and make sure that the Rational Imaging applications have been quit and no one is currently archiving or importing images on your workstation. See the section regarding user Login and Logout for instructions (page II-1).

The workspace contains a single menu which can be accessed by pressing the right mouse button (menu button) anywhere over the blank workspace. This menu is used to access the SUN utility programs provided in the DeskSet and the RI'login program launcher (workspace menu | imaging).

**Icons**

Icons are graphical representations of programs or functions. For example, instead of having a textual "Print" command, this may be replaced with a graphical button which has a picture of a printer on it. Each program in the RI system is associated with an icon representing that program's function. The RI'port program has an icon that shows a scanner and the sun with an arrow in between, representing the two way communication of images between the scanner and the SUN workstation. When each program is closed, they reside at the bottom or sides of the screen in iconic form. To open the programs, simply double click over the icon (Click the left mouse button two times quickly). Or you can open the program by putting the cursor over the icon and selecting Open from the icon's menu (icon menu | open).

To close a program to its iconic state, select the control triangle in the upper left corner of the program's main window. Or you can bring up the program window's menu which exists over any of the borders of a window and select the close option (window menu | close).
UNIX Console

The unix console normally exists as an icon at the lower left corner of the screen. This program may be opened up by double-clicking over the icon with the left mouse button. The console may be used to run programs and enter other UNIX commands. It also is the default repository for any error messages issued by UNIX applications. If a network host computer goes down, then the error message "NFS client (hostname) not responding" will appear in the console. Or if a program issues a notice to the user giving a broad error message, then look to the console for more specifics or for related problems that may have been occurring. For example, if a program notifies you that it can not save a file, then look to the console to see if a "disk partition full" message is present. This is a very useful tool when any problems arise and you are trying to understand or troubleshoot the nature of the problem.

Memory Considerations

Closing a program to its iconic state does not quit a program, nor does it relinquish the system memory and database links that might exist with the program. Therefore, if too many programs are running, either open as control windows, or closed as icons, the memory may be insufficient for image processing. Memory may be released and made available for other applications by closing the patients being used by the RI system applications, or by quitting the applications using the quit buttons provided on the main window of each program.

A quick note for those users confused by memory and disk space. Memory is RAM or random access memory, usually 32MBytes or 64MBytes, and is very rapidly accessible to programs. Disk space is very large in capacity but much slower to access. Each RI application loads the images into memory for rapid processing and display. Since memory is very quick compared to disk access, image processing functions such as bi-cubic interpolative zoom and cine-display are possible only when RAM is used effectively. Memory is not a sufficient storage device however, due to its limited capacity, and therefore could not hold hundreds of exams like magnetic disks can. Therefore disk space is used to hold images until the review process can load them into memory. These images are removed from disk when the images are archived to a long term storage device (optical disk or tape). Limited disk space will prevent the importing of additional exams or may not allow images to print, since this also requires the use of temporary disk space. It may also cause database errors if disk space becomes critical. RAM memory limitations prevent the images from being loaded and displayed, and therefore prevent various applications from functioning properly. Therefore, when done using a program, close the patient to release memory and quit the program. This policy will conserve memory and reduce the possibility of program failure.

Configuration

When a user first logs in, the Rational Imaging environment consists of the colored workspace, the control console where error messages can be retrieved, and the program launcher RI'login. This workspace environment can be modified to suit a user's particular taste or requirements. If additional programs are used often, it is useful to have these programs exist on the bottom of the so-called "image processing desktop" known as the
workspace. To do this, run the programs from the workspace menu or from the UNIX control console, close the files to iconic state, and organize the icon's location to your liking. Then choose save workspace from the utilities submenu of the workspace menu (workspace menu | utilities | save workspace). The system will confirm the success of this function. The next time you log in to the system, it will remember this layout.

The background color can also be changed to suit personal preference. Dark colors are preferable since they improve diagnostic perception. Choose the properties option from the workspace menu (Workspace Menu | Properties). When you have completed your modifications, save the workspace (Workspace Menu | Utilities | Save Workspace).

C. **GRAPHICAL USER INTERFACE**

**Keyboard**

The keyboard is used to enter your username and password, to update image annotation, and to run additional programs from the UNIX main console. The *RI* imaging system was designed to minimize keyboard interaction, since well-designed mouse functions are much faster and more intuitive. Furthermore, few of us can type proficiently in a darkened reading room required for diagnostic imaging. Therefore, the optimization of print templates and load templates discussed in future chapters will allow image annotation with minimal keyboard interaction.

For those keyboard proficiandos, additional function keys have been added by SUN to open windows, close windows, send windows to the back of the stack, or copy and paste text within the image windows. Consult your SUN manual for further information regarding the use of these keys.

**Mouse**

As mentioned in the previous section, the entire *Rational Imaging* interface was optimized for the mouse. By sliding the mouse along the pad, you can move the cursor to the desired function and click with one of the buttons to perform an operation. The first thing to remember about the type of electro-optical mouse that is provided, is that it needs to be perpendicular to the pad, and the pad should have its long axis towards you.

If you look closely at the pad, it has very fine lines, which are different horizontally than vertically. The mouse uses reflective light to determine where the mouse has moved and thus, move the cursor a similar amount. The sensitivity of the mouse has been optimized during installation, however it can be changed to suit your preference. Consult your SUN manual to perform this operation. If the optical mouse pad is problematic, SUN now offers a mechanical mouse to replace the standard optical mouse, or there are various trackballs available to suit your preferences.

The mouse provided has three buttons. The left mouse button (SELECT button) is used to select items and to perform operations like clicking a button or double clicking over the screen. Clicking refers to depressing the specified mouse button one time. Double clicking refers to depressing the left mouse button quickly two times in succession. These small variations make the mouse a very powerful tool and increase the number of functions that each button can provide. The middle mouse button (ADJUST button) is used for many non-specific purposes. The right mouse button (MENU button) is depressed to view a menu and choose an option from the displayed menu. The right button can be depressed...
continuously and the mouse moved to select the option, and then released. Or the menu button can be depressed quickly which will lock the menu open until a option is selected with the right mouse button.

The mouse can also be used to drag features of the screen. This is accomplished by placing the mouse cursor over the item (say the header of the window), depressing the left mouse button, and with the mouse button depressed, drag the window to a new location. Release the left mouse button when the drag is complete.

The status bar on the bottom border (footer) of each of the RI system windows will provide information about the current mouse operations or program status. For example, the following cryptic line \((L:\text{adjust} \ M:\text{clip} \ Dbl:\text{reset} \ shift:\text{select} \ ctrl:\text{text})\) would tell the user that the left mouse button adjusts the size or position of a clipping rectangle. The middle button would cut the image. The double click (always left mouse button) would reset the original image. When the shift key is depressed, the mouse mode will resemble the select mouse mode. When the control button is depressed, the mouse functions will emulate the text mouse mode. The right button will always display the menu of mouse functions and other options. When either the shift or control keys are depressed, the cursor changes to reflect the new mode and the status bar changes to reflect the new mouse functions. When the shift or control keys are released, the cursor resumes the current mouse mode. These modifier keys enhance the functionality of the three button and will become more clear as we proceed into the chapters on image display.

Main Windows

Main windows are defined as the primary control window for an application. They are determined by the control menu (triangle) in the upper left corner of the window. This control menu can be used to close the window (program) to its iconic state. The top of the main window is called the "header" and the bottom the "footer". The outside border of the window is called the "frame". The header usually has a title for the application and can be used to drag the window to a new location. There is also a menu over the header which allows you to open, refresh or close the window. The frame also has a menu and can be used to move the window. The footer is used to display status information about the operation of the program. The RI system uses this location frequently to display processing options and status information. Hence it is referred to as the "status bar".

Since the screen space is limited, windows can be overlapped to conserve space. Click on the header of the window to bring it to the front of the pile of windows. Or place the mouse anywhere over the desired window and press the Front function button on the keyboard. If the desired window is entirely underneath another window, put the mouse over the top window and press the Back function button. Or close the top window by pulling its pushpin (popup) or clicking its control menu (triangle on the upper left border of the main window).

Some windows can also be resized by moving the cursor over one of the resize corners. When the cursor changes shape, press the left mouse button and drag the window to new dimensions. Some of the main windows have been locked to prevent this feature, however
this is a very useful and intuitive way to increase the size of an image in a popup display window.

**Popup Windows**

During the operation of a program, several associated windows may also be used to display parameters, gather information, or display images. These "child" windows are called popup windows and are usually determined by the "pushpin" in the upper left corner. This pushpin can be used to keep the popup window in place, or it may be clicked to remove the window. When a main application is closed, all of its "child" popup windows will be closed. This makes it very easy to create a large number of image display windows and close them easily by closing the main program. Popup windows have the same components as windows such as headers, frames and footers. Popup windows can also be resized like main windows by adjusting the resize corners. When the cursor changes shape, press the left mouse button and drag the window to the desired dimensions.

**Buttons**

Buttons are used for special operations. When clicked or "pressed" with the mouse, they perform a function like saving a file, or loading a set of images. Some of the buttons have a small menu triangle in the upper right corner of the button. When this is present, it indicates that there is a menu beneath the button. If the menu button (right mouse button) is pressed while the cursor is over this button, then a menu with various options will appear. Select the option from the menu with the right mouse button. Buttons can be both textual and graphical (icons). The RI interface is full of buttons which perform specific functions. These icons and their functions will appear in the following chapters.

**Menus**

Menus are useful ways of making multiple options easily accessible. Menus can be displayed by pressing the right mouse button (menu button) over the menu triangle. Options and submenus can be selected from the menu by again clicking the right mouse button. This is one of the only times that the right mouse button is used to select options. Usually the select button (left mouse button) is used.

The workspace contains its own "workspace menu" with options about the workspace environment and various programs available to the user. Menus also exist over the header and frame of each popup and window. They also exist over icons and can offer additional options to buttons. Therefore, place the cursor over the appropriate item to obtain the desired menu. While these menus may seem hidden at times, the screen would appear too much like a "jet cockpit" if all of the options were spread over a single window. A great deal of consideration has been given to determine which functions require visible buttons and which can be hidden due to less frequent use.

In some cases, menus have been given pushpins. If you click on the pushpin, the menu will remain open. The menu can then be moved to a new location by dragging it by the header or frame. It is up to your discretion which menus to keep open on the workspace. When the
screen gets too full of these options, simply click on the pushpin to remove it and close the menu.

**Numeric/Character Prompts**

OpenWindows also allows data to be entered through numeric or ASCII character fields. To enter data into these fields, click with the mouse over the field, and then type the desired information. Additionally, numeric prompts have arrows which can be used to increment or decrement the integer values.

**Scroll Lists**

The scroll list displays multiple items in a list. The right side of the scroll list contains a scroll bar which allows the user to page or step through the information. This option will be discussed in the next section on scroll bars.

The items within a scroll list can be selected by clicking on them with the select mouse button (left). These items are toggled on and off when they are clicked. Alternatively, if you depress the left mouse button over a patient and drag the mouse down the list, all of the patients along the mouse's path will be selected or unselected.

Many scroll lists in the *RI* system have menus available over the scroll list which enhances the selection process. For example, all of the odd images, or all of the images at a specific anatomic location can be selected using one of the menus functions. The next time you see a scroll list, try pressing the menu button and see what appears...

**Scroll Bars**

At the top and bottom of the scroll bar are *cable anchors* which will display the beginning or end of the list. If you click on the *cable* (the line between the drag box and the anchors), then the list will be paged either up or down depending upon which side of the drag box was clicked. You can also position the cursor over the *drag box* and drag the list to a new location. Single step options are also present as *up and down arrows* on each side of the drag box. Play around with the scroll bars to become familiar with each of these options.

**Sliders**

Sliders are used to select numeric data within a predetermined range. The slider usually has a numeric value next to it which can be entered from the keyboard. You can use the mouse to click on the left or right *cable*, drag the *drag box*, or click the *cable anchors* to go to the minimum or maximum values. Sliders function very similarly to scroll bars.

Sliders have various functions. They can be used to display information or to select information. For example, the disk space can be illustrated as a slider to demonstrate the existence or lack of sufficient disk capacity for image transfer. A slider can also be used to
adjust the speed of a cine display. Further details on the use of sliders in the RI system will be discussed in subsequent chapters.

D. **RATIONAL IMAGING PROGRAM COMPONENTS**

**Workspace Menu**

The **RI** workspace contains a menu which can be activated by pressing the right mouse button over a blank portion of the workspace. This menu contains various options which run programs within the SUN DeskSet, or configure the system's environment. One of the options within this menu is "**Imaging**". This option executes the **Rational Imaging** program launcher **RI'login**. **RI'login** is used to control the operation of all of the other Rational Imaging applications. Execute these applications by clicking on their respective icons on the **RI'login** interface. The **Maintenance** sub-menu has many useful commands to view system performance or shut down the system. The **Manuals** sub-menu lists all available online manuals.

Furthermore, the menu can be left open by clicking on the pushpin in the upper left corner of the menu. This can be useful when multiple programs need to be selected. The menu can also be dragged up into the upper right corner of the screen where it will be easily available.

**Patient Selection**

The patient selection popup allows you to select a patient's exam from a sorted list of exams within the **RI** system. While the patient selection popup appears to be similar from application to application, the information within the patient scroll list may vary depending upon the needs of the application. An example of the patient selection popup for the **RI'port** program is shown in the figure.

The buttons at the top of the patient selection popup control the information within the scroll list. For example, when the popup is first displayed, a list of patients is generated. If one of the patient exams is selected from this list and the list series button is clicked, then a list of series for the selected patient will be displayed. Similarly, if one of these series is selected and the list images button is clicked, then a list of images for that series will be displayed. Images from this list can then be selected for processing. If a series is selected and the accept button is pressed, then the entire series is loaded or processed. Similarly, if a patient is selected and the accept button is pressed, then all of the images in all of the series will be processed. After the accept button is pressed, each program within the **RI** system will perform its own function on the images, whether it be image transfer, display, processing, or archival.

Sort options may also be present within the patient selection popup. These sort parameters can be changed by selecting the desired function from the menu, or clicking on the menu.
triangle to increment the option. After the sort option is selected, press the list patients or list images button to perform the sort.

The images will be loaded in the order that they are displayed, therefore if you wish to display an image series backwards, perform a sort by decreasing image number, select all of the images, and click on the accept button. In this manner the image sort criteria becomes a very valuable tool. For example, if you wish to view the first echo images together followed by the second echo MR images, then perform a sort by TE (echo time) and load in the images. Note however, that if a series is selected and the accept button pressed, then the images will be loaded by increasing image number no matter what value is in the image sort option.

A menu also exists over the image list in the scroll list. This menu contains valuable functions to make image selection easier. An example of this menu is shown. The select all and clear all functions are fairly self evident, however the matching functions require some definition. If the image list displays a multi-echo sequence, and only the first echo images are desired, then click on one of the first echo images and select match echo from the scroll list menu (scroll list menu | match echo). The other matching menu options perform similarly, requiring one of the images to be selected to match the attributes of that image.

**Status Bars**

The footer of the main application window displays status information about the operation of the program. For example, the RI'port program displays information about the status of an image import or export. The RI'store program displays information regarding the current state of image archival or retrieval. The RI'view program gives the user information about the mouse functions which are currently active. The image popups within the RI'view program display which popup is active with a “ACTIVE” statement in one of the image popup footers. These status bars, although rather inconspicuous, become valuable guides to each program’s operation.

Each of the programs within the SUN DeskSet displays status information in a similar fashion. This maintains consistency throughout the RI system and the OpenWindows environment.

**Warning Notices**

Warning notices are displayed if program limits are reached or an error occurs. For example, the user is warned if the system runs out of disk space or out of system memory. Unfortunately, some of these notices warn of unrecoverably system errors, and will halt operation of the program. Other notices, request confirmation or notify the user of pertinent information during the course of program operation. When one of these notices appears, pay attention to its contents and confirm your response to remove the notice. **If a fatal warning is issued, write down the message before proceeding, since this information will be valuable to technical support.**
Program Information

The question mark button on the main window of each application contains important information regarding the current application. In the event that an error is determined within the application, please use this button to determine the current version of your software. This will help determine whether the bug has been reported before and whether a solution has been determined. System upgrades will be performed to remedy problems and offer new options.

Configuration

The initial workspace that comes with the *RI* system, has been ergonomically designed for efficient image display and convenient access to each of the pertinent programs. When you become familiar with this environment, you may wish to customize the appearance and position of the program components and vary the screen parameters to suit your particular preference.

The configuration of each application, such as window placement and default startup values within the menus and options are determined by a configuration file existing in the user's home directory. These configurations can easily be updated by clicking on the **config button** and clicking on the **save configuration** button. The next time this program is run, it will return to its current location with its present options selected. This allows each user to customize his/her own desktop environment. For example, *RI'view*, *RI'port* and *RI'store* will be used sometimes simultaneously. Therefore they should be placed so that their windows do not overlap. Furthermore, since all three programs have patient selection popups, it is best to locate each of these popups at a different location on the screen to immediately and intuitively tell which is which. The image display within the *RI'view* application will be further customizable with exam template files described in subsequent chapters. User customization is one of the strong points of the *Rational Imaging* system and can simplify the complexity of the workspace.

Quit Button

The quit button on the main window of each *RI* application is used to exit each program. When the quit button is clicked, the *RI* image database is notified that this patient is no longer in-use by the program. Also, the windows are properly removed from the screen, and the X-Window system is notified of the program's completion. Furthermore, memory and temporary disk space utilized by the program is properly freed so that the UNIX operating system can distribute the memory to other applications.

Online Help Text

Help text is available over most of the components of the Rational Imaging interface by positioning the cursor over the item and pressing the “Help” key on the keyboard. After reviewing the text, click on the pushpin in the upper left corner to close the help popup.
A Quick Tour

A. Filmless Radiology: The Beginning

The ideology of filmless radiology places many new demands on the hardware and software components of digital imaging devices. This chapter will illuminate these challenges and suggest solutions which will not only accomplish these tasks, but will enhance the current practice of diagnostic visualization.

Reliable Centralized Archive

Film has long been the accepted archive media for the medical profession. State and Federal laws exist which specify the length of time the patient's diagnostic images must be kept available for review. In California, the limit is seven years. Therefore, if we are to retire film from diagnostic practice, we must address the issue of PaperFilm longevity and accuracy, or provide an alternative long term archive technology to enable reproduction of the images.

Fortunately, optical disk and helical scan tape technology allow the mass storage of images conveniently and at low cost. Optical disk media, at its current price, costs approx. $2.00 per patient, and helical scan technology (DAT or Exabyte) costs less than 5 cents per patient. Therefore, Rational Imaging has adopted the helical scan technology for its solution to patient archival. Both these tapes have been tested thoroughly for computer backup and are highly reliable. Specifications provided by the manufacturer of these drives show that unrecoverable bit errors, not including drive failure or damaged media, occur on the order of $1 \times 10^{-13}$ (Exabyte) and $1 \times 10^{-15}$ (DAT). This would result in the loss of one bit of information (small part of an image) in 125,000 or 12,500,000 exams respectively. To put this in perspective, if a facility archives 30,000 exams a year, this would result in one lost exam every 4 years for the Exabyte and every 400 years for the DAT drives respectively. At this error rate, theft, fire or physical damage becomes much more of an issue. Dual drive archiving capabilities practically eliminate the loss due to tape errors, theft, physical damage, or fire since duplicate copies can be taken off-site.

The tape drives can be located at each facility, or centrally located with a librarian to perform the archival/retrieval functions. The archive database maintains sufficient information to locate the patient's exam and determine the tape set and unique tape number even if multiple archive units are used. Manual archive logs may be printed for each tape to verify exam archival prior to removing the patient's exam from the scanner.

Quality Print Media

The quality of the print media is paramount to its acceptance by the radiologist and the referring physician. Even if the paper itself is not used for primary diagnosis, it has to be
capable of illustrating the pathology, or lack thereof, with sufficient contrast and spatial resolution.

During the exhaustive clinical and physical tests performed at our beta-test facilities, it has been confirmed that the Canon Paper Film Imager goes beyond the required greyscale reproduction work by offering full 32bit color at 600dpi resolution. At this spatial resolution, an MR image could be displayed with inherent resolution in just under one square inch. Since human visual acuity is not this refined, the print application uses bi-cubic interpolation to display the images at larger dimensions while maintaining the smooth appearance.

This Paper Film technology is not a dithered output, but relies on a proprietary translucent toner and a variable intensity laser beam to distribute the millions of available colors. In this manner, true 8bit (256 shades) greyscale is utilized to print the images. Since laser film printers use 8bit digitized video to reproduce the image, and since the Canon PFI far exceeds the spatial resolution required to reproduce the image, PaperFilm will evolve as the new diagnostic media for medical applications.

Since Canon has been in the business of quality multi-media printing for many years, their competent service staff at numerous locations will maintain the reliability and quality of the print media. Using conservative estimates of today’s film costs, the paper, toner, preventative maintenance, and service costs together are less than 1/10 of the film costs.

Networked Image Review Workstations

The image review workstations must allow a physician to examine a patient's images from anywhere on the imaging network. If the network is expanded to multiple facilities or cities, this should not prevent the transmission or review process. Current hardware technology exists to handle this requirement, in fact, UNIX was designed with networking in mind and as a multi-tasking operating system, is perfect for these applications.
The distributed design of the image database was implemented to allow each facility to maintain its own images, while allowing easy visualization from remote workstations. The centralized component of the image database, allows the physician to select any patient within the system and review it. In this manner the location of the patient becomes transparent to the end-user except that if a slow modem or ISDN communications are utilized, the image transfer will be slower than over T1, microwave, satellite, copper, or fiber-optic ethernet lines.

Similarly, the technologist, physician, or staff must be able to locate a patient's study whether it is currently in the system or has previously been archived. The RI archive database keeps track of each facility's exams and will allow patient searches by name, patient id, exam number, and inclusive dates. This enhances the reliability of the imaging system for clinical operations and reduces the manual labor involved in locating and restoring a previous procedure.

See the chapter on Database Components for more detailed description of the RI databases.

**Display 16bit Images to Full Contrast Resolution**

Most digital imaging devices today contain between 8 and 16 bits of contrast resolution (256 to 65536 shades of grey). The subtle variation in intensity within these images may determine the conspicuity of a particular pathology. Therefore it is mandatory to be able to adjust the brightness and contrast of an image to fine increments.

With film, the brightness and contrast are determined by the technologist who may, without knowing, limit the diagnostic information. PaperFilm will be optimized similarly and will only show those image intensities which have been selected for display. The digital display within the imaging workstation does not suffer from this limitation however. The image may be adjusted by the technologist, or the physician allowing complete control of the image characteristics during review. The RI system will always optimize the 16bit window and level when displayed on the screen by making sure that the selected image range is displayed through all of the available greyscales of the colormap. Although studies have shown that the human eye is only capable of detecting 32-64 shades of grey at one time, the ability to change the overall characteristics of the intensity information may enhance low contrast perceptibility.

**Network Communication with Image Scanners**

The easiest way to import image information, is to connect to the video output of the scanner and *digitize* the video. This type of image capture has many disadvantages and only one advantage. The advantage is that it is simple and universally applied. The disadvantages are as follows: 1) The intensity information is locked in by the technologist's display, therefore both bone and tissue windows need to be captured for CT images. Furthermore, the "original" image is never maintained by this type of system. 2) The patient
demographics must be re-entered with the image capture requiring additional technologist time and introducing a source of error. 3) Header information such as slice thickness, location, pulse sequence, velocity encoding range is not available unless all of the header information is entered manually. 4) The image can not be returned to the scanner for additional processing. 5) Digitized video can not be used to do quantitative analysis or advanced image processing, such as MR angiography, or 3D reconstruction. 6) Specialized digitization workstations are required for each scanner to capture the video and enter the patient demographics.

Digital transmission of the images directly from the scanner's ethernet boards to the RI imaging system maintains the images inherent integrity and patient header information. Although many legal and proprietary issues need to be addressed with regards to this type of connectivity, the advantages far outweigh the additional complexity involved. ACR-NEMA has made great progress recently at establishing a standard for image communication which is acceptable to many of the vendors. Advancement and support of this standard will advance the ideology of Picture Archiving and Communication (PACS) and will remove many of the roadblocks inherent in today's scanner connectivity.

**Human Engineered User Interface**

While it may sound like the filmless radiology system requires a staff of Ph.D. rocket scientists to operate, graphical user interfaces have emerged which dramatically improve the ergonomics of the system. **Human engineering and workflow streamlining are the most important factors in designing an efficient filmless system.** Therefore, an acceptable system MUST have a physician interface which allows diagnostic interpretation from the monitor without requiring knowledge about computer keyboards, operating systems, or network technology.

The staff at IST have concentrated their efforts on making *Rational Imaging* applications user-friendly. In fact, the RI system was developed in a clinical environment with constant operational feedback. Additional insight was gained during the beta-test phase of this development resulting in today’s highly-advanced form of image review, printing, storage, and communications capabilities.

Until recently, the hardware has not been available to accommodate all of these needs. With the emergence of high capacity archive tapes, powerful desktop display workstations, image
communication standards, and alternative inexpensive print media, PaperFilm technology will revolutionize the image review process and promote cost-effective diagnostic imaging.

The professional staff at CANON and IST greatly appreciate your purchase and support of our technology, and will strive to provide the highest quality in advanced imaging techniques to allow your facility to face the growing needs of tomorrow's diagnostic imaging.

B. RI'VIEW VERSUS GENERIC IMAGE PROCESSORS

True Digital Interfaces to Scanners

The RI system currently supports TCP/IP network protocols, Network File Sharing (NFS), and ACR-NEMA Dicom 3 image communication functions. Film digitizers are also being evaluated to incorporate x-ray films into the Rational Imaging system for remote review and archiving.

Centralized Patient Database

The centralized patient and image database allows a physician with the appropriate authorization to list the current exams, series, or images from any workstation on the network. The actual location of the images, whether on another workstation's disk or at another facility, will be transparent to the user if the workstations are linked by ethernet. Each RI workstation is configured with the appropriate software and access to the centralized database. Each user, however, must log on with his/her own password for system security. A more detailed description of the patient and archive databases will be given in the Database Components chapter and in the appendix.

Distributed Image Network Topology

The images themselves can exist on any RI system within the network. This allows easy expansion of available disk space, locates the images where they will be actually reviewed, and minimizes network traffic. This is in contrast to a centralized image architecture which would maintain all of the images on one system and would require each workstation to access the images from the central location over ethernet. While the ethernet access is not too much slower than hard disk access, the dependence on the ethernet for image review would soon overload the network and cause too many collisions. At this point, network performance (i.e. image transfer speed) would diminish rapidly.

The RI system was designed to optimize network performance, security, and disk space issues. The images are imported across the network once during the day to the appropriate RI workstation. The images are reviewed and printed from that workstation. If a second opinion is required, or if access to the images is desired from another workstation, the network traffic will increase slightly during the image load procedure, however remote access will be easily and transparently accomplished. If the technologists are trained properly, and if sufficient disk space is attached to each review workstation, then this network traffic will be minimized. At night when the network traffic is minimal, the archive procedure will go out to each of the selected workstations and archive the selected exams.

Human Engineered Graphical User Interface (GUI)

The engineers and clinical consultants have designed the Rational Imaging user interface to be as simple as possible while accommodating the complex requirements of diagnostic review. This interface allows easy display and manipulation of the images with minimal
keyboard interaction. Remember, it is difficult to even see the keys in a dark reading room, much less expect physicians to become typists.

The \textit{RI} system also automates as much of the image display and print page preparation by using user-configurable load and print templates. Physician acceptance will grow only when filmless radiology becomes easier than reading films from a view box.

\textbf{Multi Window Image Display}

Radiologists currently use multiple illuminated view boxes to display the multiple films acquired during the procedure. It is not unlikely to have 10 series, each with many images when reviewing a difficult case. The display workstation has to be designed to quickly display not only images, but multiple series without going back over the network to retrieve the next series or image.

The \textit{RI} display application, \textit{RI}'view, allows each series to be displayed in separate windows. Since all of the images are read from the local or remote disks into memory, changing between windows is very rapid. Furthermore, each window can be configured to display multiple images, or a single image depending upon the physician's preference.

Load templates simplify the display of images and are customizable for each user. For example, the first series of a Lumbar Spine MR study may be displayed in a 6 column by 4 row multi-image display. The second series may be displayed as a single zoomed image to be panned through by the physician. Each load template is customized for the type of exam and series number to match the acquisition protocols that were followed during the procedure.

\textbf{Duplicate Series Display}

A duplicate window feature allows each loaded series to be displayed in multiple windows. This allows the attributes of the images and windows to be varied without reloading the image information. This provides a highly versatile image display which is simplistic in application.

A good example of the use of this feature is in displaying CT images. Usually the physician would have to adjust the window and level to change between the tissue and bone images. With the duplicate window command, one window for a series would display the bone equivalent image, and the other window could be configured to display the tissue equivalent image. Similar applications exist in MR for multi-echo imaging sequences.
Since the duplicate window feature is also supported by the load templates, the customized image and window information can perform a great deal of the image preparation. This reduces image preparation while providing a consistent display for each type of exam.

**Display Multiple Exams Side by Side**

Since the UNIX operating system is multi-tasking, and since the image display supports the windowing environment, multiple versions of RIView can be run simultaneously to display different exams side by side. If you want to compare a previous study with the current exam, or you wish to display the CT and MR images side by side, these capabilities exist within the Rational Imaging system with only a few mouse clicks and your own imagination.

**Auto Image Preparation via Templates**

Exam load templates become a very important component of the image preparation. These templates define approximate window and level parameters to use, window characteristics and various image display parameters. Each template is customizable allowing each user to define his/her own workspace and image display. This feature reduces technologist time since the image layout is automatic and the brightness and contrast are approximated. Each time the user changes his/her own layout, the technologists do not need to be retrained or even notified.

**Global or Individual Image Customization**

Image optimization can then be performed for each exam. Optimal window and level adjustments can be adjusted and the images can be clipped to make optimal use of the display workspace. Images can be adjusted as a whole or individually, by using the image select feature. Once the desired images are selected, the window and level, the creation of duplicate windows, and the clipping in the print window is keyed to only these selected images.

**Save Exam Layout**

After the images are prepared, the technologist or physician clicks on save, confirms that the images have been prepared, and saves the current patient exam. All of the information pertaining to the screen layout, image display, annotation, and print page creation will be saved using this command. Next week, or several years from now when the exam is restored from tape, the display will appear as you have left it with everything intact.

**Customizable Print Templates**

The print templates are similar to the load templates in that they are customizable ASCII files which determine every aspect of the print page layout. If you want one image on the page, or eight small images and one large one, simply create the appropriate print template.
and label it accordingly. If you want individual image annotation such as number and window/level, or if you want the study number at the bottom of the page, this is all customizable. In fact, you can add your own permanent annotation to the print template so that it will be printed in the same place each time. Temporary annotation can also be added, by dragging the text from its temporary location over the images as necessary.

**Print Editor**

The print page display is customized to print PostScript files to the Canon printer across the network. To prevent the loss of time and paper, the screen has been designed to match the PaperFilm output exactly. Arrows, text color and size, and image position are displayed on the Print Page window as they will appear on the PaperFilm output.

**Calibrated Monitor-Printer Intensities**

The PaperFilm printer has adjustments for the linearity of greyscale output. Each system will be optimized for linear response during installation and checked during routine maintenance. Additionally, Sony monitors, and in fact most monitors, have a non-linear response to digital image intensities (i.e. it is easier to see changes in intensity in the bright intensities than it is in the dark). Therefore, the monitor response is calibrated during installation and calibration factors are built into the display program to correct for this characteristic.

The result of this careful calibration is that the image that you review on the screen will appear with the same contrast and brightness on the printed output.

**Image Annotation**

The individual images can be annotated during review to document particular anatomic anomalies with arrows or text. This is very useful if you wish to have another physician review the exam. Simply enter the text into the image, save the configuration, and when the physician at the other workstation loads the exam, he/she will be able to see your arrows and text. Additionally, this becomes useful for documenting your review for legal purposes.

The print page can also be annotated to document the presence or absence of pathology for the referring physician. This becomes a very powerful tool since with arrows or text, there is no ambiguity as to where the pathology was visualized. Many times with written reports, it becomes difficult to locate the corresponding pathology on multiple films.

**No Special Hardware Requirements**

Since PaperFilm is a toner based technology on paper rather than on film, special view boxes are not required to adequately display the images. This combined with ultra-high quality images and colored annotation at a lower cost is almost too good to be true. Prove to yourself that it is not, the system will do almost anything you desire. And if it does not, please notify your CANON or IST representatives with your suggestions.

**Centralized or Distributed Archiving**

The ability to use centralized archiving is a powerful feature. The RI system may be setup with one centralized archive node, or it may be configured to allow each department or facility to archive their own images while still providing image access to the entire imaging network. It may be advantageous to have each facility be responsibility for its own images. Or one localized facility may archive all of the exams on the network. However your
institution wishes to configure your setup, the RI'store application within Rational Imaging will accommodate your needs.

**Structured Query Language (SQL)**

The RI image and archive databases are founded on a commercial database that provides its own robust set of functions. First, it contains full record-locking and modification logs. It also is SQL (standard query language) compatible. Therefore, not only can the RI applications access information within the database, third party SQL applications can also use this information. This adds the potential of linking the imaging database to other radiology information systems (RIS) or hospital information systems (HIS). It also allows other applications to link in their own tables to collect research or proprietary information regarding the patient exam. Details on the image and archive database are given in the chapter on database components, and in the appendix. We provide the database architecture as a service to our customers, allowing them to incorporate their own specialized applications.

**Customizable Workspace**

Most of the important aspects of the imaging environment are user configurable, so that when you log in each day, your system will return to your custom configuration. Screen color, placement of program icons, appearance and location of the application windows and their associated popups, and most of all, user configurable templates which define much of the image preprocessing and display characteristics. Since it is impossible to be all things to all people, we supply you with the tools and initial defaults, and then allow you to configure your own personalized image review environment. To this end, both Canon and IST would be happy to hear your thoughts on better layouts, templates and additional customization.

**Reliability**

Since the RI system is dependent upon database information for a seven year period or more (to list archived patients), patient backups along with database backups are paramount to providing reliable filmless technology. Since you can never prevent disk failure from occurring, and the cost of doing mirroring or using RAID technology becomes prohibitive, we have established protocols for archiving and system backup which ensure exam integrity. For example, whenever a new archive tape is initialized, both the image and archive databases are backed up onto the tape. This costs very little in terms of tape capacity or time, yet the reliability of the system is dramatically improved. To restore a system after a disk crash, simply reload the system software, insert the last tape in the series, and run the rebuild_archive script described in the installation manual. Both the archive and image databases will be restored to disk. Then the script will update the archive database with exams appended to the last tape. Finally, since the disk failed and all of the exams on the
disk were lost, simply import them from the scanner. One of our protocols recommends that the archive is done every night. The next day, when the archive is verified, the images can be removed from the scanners. This will minimize the risk of hard disk failure causing the loss of an exam.

Since the workstations are networked together, and it will be difficult to tell which exams are being read at remote workstations, several flags have been added to the database to notify a user if the patient is currently in-use. This will prevent you from overwriting a patient layout with your own, or removing a patient during archival when someone is reviewing the case. Additionally, even if you are not using the case and want to have it remain on the system for a week, simply set the Lock flag in the database and no one will be able to remove the patient until the lock is removed.

It is also difficult to determine when a scanner will go down, or a network glitch will cause a transfer to malfunction. Therefore, before any patient transfer, a completed flag is set to No. At the end of the exam's transmission, the completed flag is returned to Yes. RI'port, the import/export application, will report any patients which are not complete. This is normal if the transfer is in progress, however if you know that the scanner has just gone down, it becomes a very useful tool to see which patients were affected. Simply retransmit those patients that were not imported or exported properly.

**Accountability**

When a physician sets a lock flag, reviews a case, prints a case, or dictates a case, it would be nice to know that these operations have been performed and by whom. You can! Each time you close the exam in RI'view, the system records the operations that have been performed (Review, Dictate, Print). This procedure will link your username (which is password protected) with the appropriate function(s) performed. Several years from now when a case is restored from tape, it is a simple task to find out who performed these functions, or whether they were performed at all.

**Security**

The workstations can be configured to allow or reject commands from foreign workstations. Furthermore, each user is issued his/her own account and password and it is their responsibility to keep their password secret and change it often to minimize unauthorized access. If the system needs to be left on overnight to backup the images onto tape, then the screen can be locked via software so that only the correct password will unlock the screen. This will prevent the janitor or a disgruntled employee from altering the system.

The archive tapes are especially prone to tampering, since each tape contains over 200 patients. It is recommended practice to make two backups and maintain one copy at an offsite location. RI'Store was designed to allow multiple tape sets (e.g. the primary set and a secondary set for retrieving exams). It is also configurable to use whatever tape devices exist on the system. Archive the patients onto the primary archive with auto-remove set to off. This will increment the archive flag for each exam to 1. Then select these patients that
have already been archived, for backup onto the secondary set enabling the auto-remove function. The secondary archive can be performed the next evening allowing the exams to remain in the system for a full day.

Each user can secure his/her own account and make sure that sensitive data is restricted to other users.

**Upgradable Workstations**

The SparcStation 10 is recommended due to its advanced power and display capabilities. It is also upgradable to a multi-processor system if more speed is desired. The cost of the upgrade is a fraction of the cost of having to buy a new computer, or even worse, being limited by the speed or memory capacity of an inadequate workstation.

The memory and disk space can also be user configurable. If you are a power user and wish to have many patients and applications loaded at the same time, then simply install up to 128MB of memory. If you add additional scanners and now need to review more images at the workstation, add another internal 3.5GB disk or a series of external 3.5GB disks to the workstation. Then simply tell the database that these disks exist and they will be available for image storage. You do not need to throw out the old disk just because it is too small!

**Multiprocessing Operating System**

The multiprocessing capabilities of UNIX make it the perfect operating system for image processing. Each of the separate functions such as import/export, image review, and archival were designed as separate functions so that they could be run independently and simultaneously. For example the RI'store application can be running dedicated image archival at the same time that you are reviewing cases because it runs in the background using less than 5% of the CPU. Similarly, you can be reviewing a case at the same time you are using RI'port to import the next case to your workstation.

**A Glance at the Future**

*Rational Imaging* was designed as a platform for versatile image review and processing. We would be amiss if we did not already have additional applications in the works to suit your particular needs and make greater use of your hardware purchases. These will become available as they are scrutinized, perfected, validated, and approved by state and federal regulatory agencies.

<table>
<thead>
<tr>
<th>Advanced image processing</th>
<th>RI'format</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR angiography</td>
<td>RI'project</td>
</tr>
<tr>
<td>Digital dictation</td>
<td>RI'verb</td>
</tr>
<tr>
<td>Cardiac analysis package for MRI</td>
<td>RI'cap</td>
</tr>
<tr>
<td>MR quantitative flow package</td>
<td>RI'flow</td>
</tr>
<tr>
<td>DICOM image communication</td>
<td>RI'dicom</td>
</tr>
<tr>
<td>Intelligent image management</td>
<td>RI'distribute</td>
</tr>
<tr>
<td>Versatile report generation</td>
<td>RI'query</td>
</tr>
<tr>
<td>RIS interface for reports and pre-fetch</td>
<td>RI'link</td>
</tr>
<tr>
<td>Report Viewer (Text / JPEG / GIF support)</td>
<td>RI'observe</td>
</tr>
</tbody>
</table>

We also advocate the addition of third party software, such as word processors, graphics applications, or other personal software. You should be able to use your *Rational Imaging* workstation for your entire computer requirements.
C. THE IMAGING PROCESS: AN OVERVIEW

Rational Imaging consists of a platform of 3 required programs, and other advanced applications to fulfill a user's particular needs. The three main applications that are standard with the Rational Imaging workstation consist of RI'port, RI'view and RI'store. These applications embody the import/export, image review, and archival processes respectively.

Image Import/Export: RI'port

In order to review images within a remote workstation, the images first need to be transferred to the workstation. RI'port allows you to obtain a list of patient exams from a selected networked scanner. You may then select an exam or exams for importing to a selected local destination. The scanner is notified of the request and the bottom footer of the RI'port window (status bar) reports the image numbers in progress. RI'port does not need to be used to transfer images within the RI system, since they are already in the database and are easily available over the network. Generally, the technologists are responsible for importing the exams once the exam is complete. If you have multiple RI workstations, and particular exams are read on the individual workstations, have the technologists transfer the images to the workstation where the images will be read. This will minimize the network traffic and improve system performance.

Image Review/Printing: RI'view

Once the images have been transferred to the RI system, any of the RI workstations can view and print the images. The user simply clicks on the select patient button on the main window of the RI'view program to obtain a list of exams currently in the system. Any of these exams may be selected and loaded into memory no matter where they exist within the system. If multiple facilities are connected via satellite or by a T1 line, then the images will be transparently loaded from that location.

When the images are loaded into memory, each series will be displayed in separate windows using the default characteristics established in the selected load template. One of these windows is active at a time and designated as the active image window. This active window is determined by the appearance of "Active..." in the footer of that window. Window, level and other image processing options will only be applied to the selected images within that window. By default, all of the images are selected unless the user selects individual images using the select mode. Along with the image windows, the tool popup is also opened to allow the various processing modes to be selected.

The mouse mode buttons within the tool popup allow the user to select the specific functions of the mouse.

- View1 (MR/CT): The view1 mode changes the image visualization mode and allows the mouse to page forward and backward within the selected window. If the mouse is
dragged up, down, left, or right, then the page of images will be incremented or decremented accordingly.

- **View2 (Xray/DR):** The view2 mode changes the image visualization mode and allows the mouse to change the image brightness and contrast or display a magnifying glass to enhance high-frequency image detail.

- **Text:** The text mode allows the images and the print window to be annotated.

- **Print:** The print mode allows a Print Page to be created, displayed, zoomed, or deleted.

- **Window/Level:** The window/level mode allows the user to adjust the contrast (window) and brightness (level) of the selected images by dragging the mouse horizontally (contrast) or vertically (brightness).

- **Window/Level Region:** The regional window/level mode allows the user to select a rectangular region for the image window/level techniques to be applied. This optimizes the histogram and greyscale intensity techniques for a particular diagnostic region of the image and excludes non-diagnostic regions outside of the rectangle.

- **Clip:** The clip mode allows the user to clip (crop) the central part of the diagnostic image and save screen space.

- **Select:** The select mode allows the mouse to select individual images within the selected image window. These selected images will be adjusted during the window level function, or the images that will be duplicated during the **duplicate window** function described in the Advanced Image Display chapter.

- **Pan:** This mode enables the operator to pan images which have been clipped to center them within an image window. This may be useful when viewing very large images in a small window at full resolution.
These functions can either be selected from the tools popup or the menu which is present over each image. The status bar on the bottom left corner of RI'view will display the active mouse functions. Each of these modes will be described in greater detail in subsequent chapters.

To change the active image window, click on the next window icon, or click anywhere over the image window with the select (left) mouse button. When the window becomes active, the cursor changes to reflect the active mouse mode and the footer of the image windows displays "Active...". Each of the functions described in the previous paragraph will then be active in the newly selected window. To display another page of images, use the view mode or click on the next page button. In this manner all of the images can be reviewed.

To change the image size, position the cursor over one of the resize corners of the window and drag the corner to the desired position. This ability to control the size of the images is applicable to any image window except the Print Page. This print window is maintained at two sizes to minimize the number of fonts required to display the WYSIWYG print page. This reduces memory requirements and improves speed.

To reposition the image window, simply position the cursor over the header or frame of the window and drag it to a new location. The window can be closed by removing the pushpin from the upper left corner of the popup window.

When the image review is completed, close the patient and release memory by clicking on the save button and then on the save and close button. Or you can choose discard changes to close the patient without saving the current patient's display characteristics.

**Image Storage/Retrieval: RI'store**

RI'store allows you to archive the days exams, or retrieve a patient's exam from a previous tape. Archive, search and retrieve buttons exist to perform the functions of exam archival, locating an archived patient in the archive database, and retrieving the exam from the designated tape.

Click on the archive button to display a list of patient's currently within the RI system. Select the exams that are not in-use for backup and automatic removal. Insert the correct tape specified on the main RI'store console (generally the last tape in the tape set), and click the start archive button to begin the backup.

Click on the search button to locate a patient's exam based on the demographic information you entered. For example, enter a few characters of the patient's last name and click on the start search button. The patient scroll list within the search popup will display a list of patients that match the first characters of the name. Determine from the scroll list which patient is desired and verify the name of the tape set, the tape number and the patient position for the retrieve function.

To retrieve a patient, select the designated tape set and tape number and click on the retrieve button. The tape log for the defined tape will be displayed in the scroll list. Select the
patient's exam based on the name or position on the tape. Click on the start retrieve button to begin restoring the patient to the RI system from the tape.

These basic applications provide all of the functionality required for a versatile filmless review workstation. The following chapters will discuss each of these applications in much greater detail.
IV. Database Components

A. Brief Description

During installation, information describing the RI image workstations, networked scanners, and available storage devices (tape drives and disks) was entered into the RI database. The main image database is located on one of the selected RI workstations. During image import, the patient's exam is transferred onto one of the available system's disks, and the image database is updated with patient demographics, exam, series and image information. Four main tables keep track of the current image and patient information: 1) Patient, 2) Exam, 3) Series, and 4) Image. The relational architecture of this database allows versatility and simplicity since a patient may have several exams, an exam may have multiple series, and a series may have many images. The indexed relational links between these tables allow efficient access to every aspect of the patient's information, and maintain system integrity. There are also additional system tables which define the operational aspects of the RI system.

When the images are archived, the patient and exam information is stored along with the patient's images on sequential tape archives. During this archival process, the exam information is transferred to a set of archive tables. These tables maintain the tape logs and allow database searches to determine which tape number and position will be required to restore the patient and exam information. The archive database contains the following tables: 1) Archive, 2) Tape, 3) ArcExam, and 4) Comments.

As a user of this system, further information on the database structure is not necessary to operate every functional aspect of the system, however more detailed information is provided for completeness in the appendix.
B. **Centralized or Distributed Architecture?**

The *RI* database was designed with both centralized and distributed components to address both performance and security issues inherent in picture archiving and communications systems (PACS). The demographic and exam information is located in a centralized database at one of the selected *RI* workstations. This allows a physician to obtain a complete list of exams, and review the images no matter where they are located. The images themselves are organized in a distributed fashion so that they may be retained by the scanning facility, a dedicated review workstation, or at the centralized archive node. If several facilities are networked together, the centralized component of the patient and exam demographic information allows easy access to the data no matter where it is located, while the distributed nature of the images allows the images to be retained within the physical walls of the imaging facility where they will normally be read. If a second opinion is desired, anyone at one of the other networked facilities can easily review these images due to this unique design and implementation.

The *RI* database is located on one of the selected *RI* workstations called the “database server”. Several databases can be created and are controlled by the main system database known as “rilogin”. This database controls user access to the patient databases within the system. This database must be specified by the RILOGDB environment variable (setenv RILOGDB //dbserver/db/rilogin) in each user’s startup shell file “.cshrc”.

For additional security, the system was designed so that each department or facility may have its own *RI* database. The upside of this architecture is that the image and patient information may be secured from unauthorized review. The downside is that second opinions and outside review become more difficult. Since each user within the *RI* system is authorized to use the system with his/her own password, and this username and password are maintained with the review and analysis software, this will provide adequate security for most imaging facilities. After all, the ultimate objective of PACS is to offer distributed image review for all authorized personnel.

C. **Database Architecture**

The *Rational Imaging* system consists of a minimum of 2 databases. The first is the main system database which defines the authorized users and image databases accessible within the PACS network. The second database, is the actual image database. There may be several image databases, depending on the nature of the imaging environment, network architecture, and political climate.

**DO NOT modify the information in these databases in any way, since each of the programs rely on the integrity of this information.** Programs may be developed, however, which extract various information from the database tables. Users who are familiar with SQL and who would entertain such a quest are directed to contact our technical support hotline prior to any database queries or modifications.

Both the user and image databases will be discussed in detail in the following sections.

**User Login Database**

The user database is usually initialized as "rilogin.dbs", and controls which image databases you are given access to. When you log in using *rilogin*, the system checks your password and then allocates any databases that you have been given access to by the system administrator. Usually, there will be only one image database since this is the easiest to implement and maintain. The following tables and variables are included in the user
Chapter 4. Database Components

database. Note that this list may change at any time, depending on the requirements of future system enhancements. Even so, it was felt that it should be included in this section to make you familiar with the nature and complexity of the system.

**Databases**

1. db_key serial 4 unique sequential key
2. db_name char 20 database name (radiology)
3. db_dir char 128 database directory (/dbhost/db)
4. user_key int 4 link to user if restricted
5. restricted short 2 restricted database (0=No)
6. alias char 32 Name for database (unique)

**Users**

1. user_key serial 4 unique sequential key
2. username char 8 username for individual
3. alias char 28 Alias or actual name
4. tmplt_dir char 128 default directory for templates
5. deflt_dir char 128 default directory for defaults
6. print_dir char 128 default directory for print files
7. current_db int 4 current database used by user
8. user_pw char 16 User Password (encrypted)
9. authlev short 2 Authorization group (link to authgroup table)
10. email char 64 Email address
11. active short 2 Is the user active (0=No, 1=Yes)
12. cur_host int 4 Current host the user is logged into

**Host**

1. host_key serial 4 unique host ID
2. hostname char 32 unique hostname
3. alias char 34 unique name of host
4. active short 2 Is the host active (0=No, 1=Yes)
5. cpu char 8 Type of CPU (Sparc, Intel)

**Image Database**

This database is usually called "radiology.dbs" and consists of many relational tables which control the exam and patient demographic information. This database also controls various system parameters within a particular RI system, such as tape drive attributes, tape archive sets, and remote scanners which may be attached to the network. Each table and the variables associated with it will be specified in this section.

The information provided in this chapter, is current as of the printing of this manual. A program has been provided so you can obtain the most current information regarding the database variables and tables in the system. To operate this program, go to the IST installation directory "/home/ist/admin" and run the program *risetup* (select *list_tables* from the menu). The first part of the program will list information summarizing the tables: 1) table name, 2) who owns the table, 3) the number of columns (variables) in each table, 4) the total space occupied by of each row, and 5) the number of rows (data items). The second section will break each table down into its columns and will specify: 1) table name, 2) column name, and 3) position. This information can be used to query the database from software outside of the Rational Imaging system.

Since the database platform is a commercial platform supporting structured query language (SQL), it is possible to extract data from the database and perform queries from independent software. These sections are provided to allow access to the open architecture and support independent query. **Use caution when using the database in this fashion, as any database changes may alter the intended operation of the RI applications.**
# Exam Information

<table>
<thead>
<tr>
<th>Patient</th>
<th></th>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pat_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential patient key</td>
</tr>
<tr>
<td>pat_name</td>
<td>char</td>
<td>28</td>
<td>patient name</td>
</tr>
<tr>
<td>pat_no</td>
<td>char</td>
<td>12</td>
<td>patient id number</td>
</tr>
<tr>
<td>weight</td>
<td>short</td>
<td>2</td>
<td>weight in pounds</td>
</tr>
<tr>
<td>height</td>
<td>short</td>
<td>2</td>
<td>height in inches</td>
</tr>
<tr>
<td>age</td>
<td>short</td>
<td>2</td>
<td>age in years</td>
</tr>
<tr>
<td>sex</td>
<td>char</td>
<td>1</td>
<td>sex [M,F,U]</td>
</tr>
<tr>
<td>dob</td>
<td>date</td>
<td>4</td>
<td>Date of Birth</td>
</tr>
<tr>
<td>getfromtape</td>
<td>short</td>
<td>2</td>
<td>Internal archiving value</td>
</tr>
<tr>
<td>ssn</td>
<td>char</td>
<td>16</td>
<td>Social Security Number</td>
</tr>
<tr>
<td>private</td>
<td>short</td>
<td>2</td>
<td>VIP exam (1=Y, 9=No)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam</th>
<th></th>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exam_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential exam key</td>
</tr>
<tr>
<td>pat_key</td>
<td>int</td>
<td>4</td>
<td>relational link to patient table</td>
</tr>
<tr>
<td>exam_no</td>
<td>int</td>
<td>4</td>
<td>patient’s exam number</td>
</tr>
<tr>
<td>n_series</td>
<td>short</td>
<td>2</td>
<td>number of series</td>
</tr>
<tr>
<td>desc_key</td>
<td>int</td>
<td>4</td>
<td>relational link to exam_desc table</td>
</tr>
<tr>
<td>exam_date</td>
<td>date</td>
<td>4</td>
<td>date of exam</td>
</tr>
<tr>
<td>hosp_key</td>
<td>int</td>
<td>4</td>
<td>relational link to hospital table</td>
</tr>
<tr>
<td>host_key</td>
<td>int</td>
<td>4</td>
<td>relational link to scanner (host table)</td>
</tr>
<tr>
<td>dir_key</td>
<td>int</td>
<td>4</td>
<td>relational link to image_dir</td>
</tr>
<tr>
<td>use_host</td>
<td>int</td>
<td>4</td>
<td>relational link to host where in use</td>
</tr>
<tr>
<td>use_user</td>
<td>int</td>
<td>4</td>
<td>relational link to user using exam</td>
</tr>
<tr>
<td>use_program</td>
<td>short</td>
<td>2</td>
<td>program which is using the exam</td>
</tr>
<tr>
<td>modality</td>
<td>short</td>
<td>2</td>
<td>exam modality (MR,CT,US,NM...)</td>
</tr>
<tr>
<td>archive_uk</td>
<td>short</td>
<td>2</td>
<td>number of times exam archived</td>
</tr>
<tr>
<td>print_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user who printed</td>
</tr>
<tr>
<td>dictate_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user to dictated</td>
</tr>
<tr>
<td>review_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user who reviewed</td>
</tr>
<tr>
<td>locked_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user who locked</td>
</tr>
<tr>
<td>prepare_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user who prepared</td>
</tr>
<tr>
<td>transfer</td>
<td>short</td>
<td>2</td>
<td>status of image transfer (0=complete)</td>
</tr>
<tr>
<td>refer_key</td>
<td>int</td>
<td>4</td>
<td>relational link to referring table</td>
</tr>
<tr>
<td>history</td>
<td>char</td>
<td>60</td>
<td>brief history of patient</td>
</tr>
<tr>
<td>exam_time</td>
<td>time</td>
<td>4</td>
<td>Time exam was acquired</td>
</tr>
<tr>
<td>import_date</td>
<td>date</td>
<td>4</td>
<td>Date exam was imported to PACS</td>
</tr>
<tr>
<td>import_time</td>
<td>time</td>
<td>4</td>
<td>Time exam was imported to PACS</td>
</tr>
<tr>
<td>age</td>
<td>short</td>
<td>2</td>
<td>Age of patient at time of exam</td>
</tr>
<tr>
<td>age_mod</td>
<td>char</td>
<td>1</td>
<td>Age modifier (y/m/d)</td>
</tr>
<tr>
<td>lock_date</td>
<td>date</td>
<td>4</td>
<td>Date the exam will be unlocked</td>
</tr>
<tr>
<td>altered</td>
<td>short</td>
<td>2</td>
<td>Has the exam been altered (saved)?</td>
</tr>
<tr>
<td>priority</td>
<td>short</td>
<td>2</td>
<td>Stat exam (1=Yes, 9=No)</td>
</tr>
<tr>
<td>last_access</td>
<td>date</td>
<td>4</td>
<td>Date of last exam access (review).</td>
</tr>
<tr>
<td>accession</td>
<td>char</td>
<td>32</td>
<td>Exam accession number from RIS</td>
</tr>
<tr>
<td>ris_status</td>
<td>short</td>
<td>2</td>
<td>Reconciled with RIS worklist? (0=No, 1=Yes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series</th>
<th></th>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ser_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential series key</td>
</tr>
<tr>
<td>exam_key</td>
<td>int</td>
<td>4</td>
<td>relational link to series table</td>
</tr>
<tr>
<td>ser_no</td>
<td>int</td>
<td>4</td>
<td>series number</td>
</tr>
<tr>
<td>desc_key</td>
<td>int</td>
<td>4</td>
<td>relational link to ser_desc</td>
</tr>
<tr>
<td>n_images</td>
<td>short</td>
<td>2</td>
<td>number of images</td>
</tr>
<tr>
<td>img_type</td>
<td>short</td>
<td>2</td>
<td>image type (GE,Raster,Gif,Tiff)</td>
</tr>
<tr>
<td>orient</td>
<td>short</td>
<td>2</td>
<td>image orientation (Ax,Sag,Cor,Obl)</td>
</tr>
</tbody>
</table>
Chapter 4. Database Components

8. psdname char 16 MR pulse sequence name
9. operator char 4 Technologist’s initials
10. coil char 16 Name of the MR coil used
11. contrast short 2 Contrast used in this series (1=Yes)
12. sub_series char 1 Series number modifier (a/b/c…)

**Image**
1. img_key serial 4 unique sequential image key
2. ser_key int 4 relational link to series table
3. img_no int 4 image number
4. tr real 4 MR relaxation time in usec
5. te real 4 MR echo time in usec
6. location real 4 image location in cm
7. qrs real 4 image acq time relative to qrs complex
8. window short 2 image window or contrast
9. level short 2 image level or brightness
10. r_ctr real 4 center right-left coordinate
11. a_ctr real 4 center anterior-posterior coordinate
12. s_ctr real 4 center superior-inferior coordinate
13. thick real 4 slice thickness in mm
14. space real 4 spacing in mm (=thickness+gap)
15. x_pixsiz real 4 horizontal pixel size in mm/pixel
16. y_pixsiz real 4 vertical pixel size in mm/pixel
17. width short 2 image width in pixels
18. height short 2 image height in pixels
19. depth short 2 image depth in bits
20. compress short 2 image compression flag (1=none)
21. ti real 4 MR inversion time in usec
22. fov real 4 field of view in cm
23. venc short 2 MR velocity encoding in cm/sec
24. flip short 2 MR flip angle in degrees
25. r_norm real 4 right-left normal vector
26. a_norm real 4 anterior-posterior normal vector
27. s_norm real 4 superior-inferior normal vector
28. postn short 2 patient position (supine, head first)
29. r_tl real 4 top left RL coordinate
30. a_tl real 4 top left AP coordinate
31. s_tl real 4 top left SI coordinate
32. nex real 4 MR number of excitations
33. r_tr real 4 top right RL coordinate
34. a_tr real 4 top right AP coordinate
35. s_tr real 4 top right SI coordinate
36. kvp integer 4 CT kvp used
37. ma integer 4 CT ma used
38. tilt real 4 CT tilt
39. table_ht real 4 CT table ht
40. file_no int 4 Image extension number (RI.####)
41. file_offset int 4 Byte location of image in this file
42. orig_width short 2 Width of acquired image
43. orig_height short 2 Height of acquired image
44. plane short 2 Plane of image (Like series orientation)
45. pt_orient char 8 Patient orientation DICOM (et: L\F)
46. img_time datetime 8 Time image was acquired “12:24.336”.
47. cassette_size char 16 Size of a acquisition devices detector (14INX17IN)
48. photointerp short 2 Photometric Interpretation (if 1, Invert the image)

**Examlist**
1. exam_key serial 4 unique sequential key
Chapter 4. Database Components

5.3.01

2. examtext char 128 Text used in patient display under Referring Selection
3. exam_no char 16 Exam_no (see exam)
4. exam_date date 4 Date of exam (see exam)
5. modality short 2 modality (see exam)
6. pat_name char 16 pat_name (see exam)
7. refer char 16 referring (see refer)
8. refer_key int 4 referring (see refer)
9. dictate_uk int 4 User who performed dictation (see exam)
10. direc char 16 Exam directory (see imagedir)
11. dir_key int 4 Exam directory key (see imagedir)
12. scanr char 16 Scanner (see exam)
13. host_key int 4 Scanner (see exam and host)
14. descr char 28 Exam description (see exam)
15. import_date date 4 Date exam was imported (see exam)
16. examtextloc char 128 Text used in patient display under Location Selection
17. private short 2 VIP exam
18. priority short 2 STAT exam?
19. pat_key int 4 Link to patient table with pat_key
20. altered short 2 Exam was altered (saved)?
21. archive_uk short 2 Archived number of times? (0, 1, 2)
22. desc_key int 4 Link to exam description
23. hosp_key int 4 Link to hospital table
24. use_user int 4 Link to user if in-use
25. lock_uk short 2 Is the exam locked?
26. prepare_uk short 2 Has the exam format been saved?
27. transfer short 2 Is the exam complete, or still being transferred?
(0=Complete)

Patlist
1. pat_key int 4 Unique patlist ID (linked to patient table)
2. pat_name char 22 Short name of patient
3. pat_no char 12 Patient Medical Record Number (MRN)
4. sex char 1 Patient gender (M, F, O)
5. private short 2 Is the patient a VIP (requires privacy)
6. text char 71 Patient list text for the RIdisplay patient selection popup.

AuthGroup
1. key serial 4 Unique authorization group ID (linked to authgroup in users)
2. groupname char 32 Name of the group (Radiologist, Administrator…)
3. deleteexam short 2 Permission to delete an exam
4. jukemaint short 2 Permission to Stop/Reset the jukebox
5. archive short 2 Permission to archive exams
6. retrieve short 2 Permission to retrieve exams from the jukebox
7. saveexam short 2 Permission to save the exam format
8. alterdemog short 2 Permission to alter the patient demographics (Name etc)
9. dictate short 2 Permission to dictate an exam
10. clearflags short 2 Permission to clear operational flags for an exam
11. viewvip short 2 Permission to review VIP (private) exams
12. print short 2 Permission to print exams.

Archive Database

Archive
1. arc_key serial 4 unique sequential key
2. last_tape short 2 last tape initialized for this set
3. db_name char 20 name of the tape set
4. host_key int 4 not used anymore
5. auto_remove char 1 auto-remove option [Y,N]
### Tape
1. *tape_key* serial 4 unique sequential key
2. *arc_key* int 4 relational link to archive table
3. *arc_date* date 4 date tape was initialized
4. *tape_no* short 2 tape number
5. *version* short 2 version of the tape information
6. *last_pos* short 2 last available position on the tape
7. *blocksize* short 2 block size used on this tape
8. *mbytes* short 2 capacity of tape in Mbytes
9. *offsite* short 2 Is the tape onsite or unretrievable?

### ArcExam
1. *aexm_key* serial 4 unique sequential key
2. *tape_key* int 4 relational link to the tape table
3. *position* short 2 position on tape (tape file=position*2)
4. *pat_name* char 28 patient name
5. *pat_no* char 12 patient ID number
6. *sex* char 1 patient gender
7. *diskspac* int 4 disk space required for this exam
8. *exam_no* int 3 exam or study number
9. *desc_key* int 4 relational link to exam_desc
10. *exam_date* date 4 date of exam
11. *modality* short 2 image modality (MR, CT, US, NM)
12. *n_series* short 2 number of series for this exam
13. *n_images* short 2 number of images total in all series
14. *hosp_key* int 4 relational link to the hospital table
15. *review_uk* short 2 relational link to user who reviewed
16. *dictate_uk* short 2 relational link to user who dictated
17. *refer_key* int 4 relational link to referring

### Comments
1. *com_key* serial 4 unique sequential key
2. *aexm_key* int 4 relational link to arcexam table
3. *comments* char 128 comments
4. *key_words* char 32 key words

### System Files
#### Host
1. *host_key* serial 4 unique sequential key
2. *hostname* char 32 hostname of computer
3. *type* short 2 type of system (scanner or computer)
4. *alias* char 34 Alias used in menus for host
5. *active* short 2 Is the host active [1=yes, 0=no]
6. *dflt_prt* int 4 Default printer for this host.

#### Users
1. *user_key* serial 4 unique sequential key
2. *username* char 8 username
3. *alias* char 28 Alias used in menus for the individual

#### ImageDir
1. *dir_key* serial 4 unique sequential key
2. *host_key* int 4 relational link to host table
3. *dirname* char 32 pathname of directory (/host/img)
4. *alias* char 24 Alias for image directory

#### Hospital
1. *hosp_key* serial 4 unique sequential key
2. *name* char 32 name of hospital
### Chapter 4. Database Components

#### Exm_Desc
1. key serial 4 unique sequential key
2. descr char 28 exam description

#### Ser_Desc
1. key serial 4 unique sequential key
2. descr char 28 series description

#### Referring
1. refer_key serial 4 unique sequential key
2. name char 28 referring physician name

#### Tape Drive
1. drive_key serial 4 unique sequential key
2. host_key int 4 relational link to host table
3. device char 24 device (/dev/nrcht0)
4. blocksize short 2 block size (20)
5. alias char 28 alias for tape drive
6. mbytes short 2 capacity of drive (3000)
7. time int 4 accumulated time in use in sec
8. cleantime int 4 time till cleaning required in sec
9. status short 2 Status of the device (0/1 = ready/busy)
10. type short 2 Type of device (1/2/3 = tape/jazz/mo)
11. devicedir char 32 Mount point for device if MO or CDROM

#### Printers
1. prt_key serial 4 unique sequential key
2. prt_name char 16 printer name
3. prt_alias char 28 alias for printer
4. type int 4 Type of printer
   1=canon
   2=cemax
   3=SeeMor B/W
   4=SeeMor Color
   5=Internet B/W
   6=Internet Color
   7=SeeMor Color w/Thumbnail
5. host_key int 4 Host printer is attached to if remote printer
6. print_dir char 128 Directory to deposit print page (/img/print default)
7. width short 2 Default width of print page in 100ths of an inch
8. height short 2 Default height of print page in 100ths of an inch
9. resolution short 2 Default resolution in dots per inch
10. print_cmd char 128 Command to be execute instead of the lp command
11. jpeg_qual short 2 Default JPEG quality if compressed printpage (20-90)
12. pt_info short 2 Print patient info (0=No, 1=Yes) Allows teaching files to FTPbook

#### FTPbook
1. ftp_key serial 4 unique sequential key
2. username char 16 Username for ftp account
3. passwd char 16 Password for ftp account (encrypted)
4. ipaddr char 16 IP Address of ftp account (or hostname if in /etc/hosts)
5. dir char 64 Directory to deposit images on remote ftp system
6. descr char 64 Description of ftp recipient

#### Phonebook
1. phone_key serial 4 unique sequential key
2. name char 32 Name of recipient
3. areacode char 16 Phone number area code
4. modenum char 16 Phone number of modem
5. phonenum char 16 Phone number of voice
6. modemspeed int 4 Speed of modem (eg: 38400) in bits/second
### Chapter 4. Database Components

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>modem_key</td>
<td>int</td>
<td>4</td>
<td>Modem to use when sending to this recipient</td>
</tr>
<tr>
<td>next_phone</td>
<td>int</td>
<td>4</td>
<td>Next modem to try if this one busy</td>
</tr>
<tr>
<td>max_retry</td>
<td>short</td>
<td>2</td>
<td>Maximum number of redial attempts if busy</td>
</tr>
<tr>
<td>call_first</td>
<td>short</td>
<td>2</td>
<td>If not a dedicated modem line, call first = 1</td>
</tr>
<tr>
<td>descr</td>
<td>char</td>
<td>64</td>
<td>Description of the Modem Recipeint</td>
</tr>
</tbody>
</table>

#### Jukebox

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>juke_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key for each jukebox</td>
</tr>
<tr>
<td>host_key</td>
<td>int</td>
<td>4</td>
<td>Host key of workstation jukebox is attached to</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status (0/1/2/3 = READY/BUSY/STOPREQ/UNLOADED)</td>
</tr>
<tr>
<td>device</td>
<td>char</td>
<td>24</td>
<td>Device name (/dev/ch0)</td>
</tr>
<tr>
<td>manufact</td>
<td>char</td>
<td>24</td>
<td>Manufacturer name (Qualstar/Spectrologic/ADIC)</td>
</tr>
<tr>
<td>alias</td>
<td>char</td>
<td>32</td>
<td>Alias name to be used in the menus</td>
</tr>
<tr>
<td>archiv_typ</td>
<td>short</td>
<td>2</td>
<td>Type (1/2/3 = Initial/Active/Combined)</td>
</tr>
</tbody>
</table>

#### Jukedrive

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>jdrv_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key for each jukebox drive</td>
</tr>
<tr>
<td>juke_key</td>
<td>int</td>
<td>4</td>
<td>Jukebox attached to</td>
</tr>
<tr>
<td>drive_key</td>
<td>int</td>
<td>4</td>
<td>Tape drive information</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status (0/1 = Ready/Busy)</td>
</tr>
<tr>
<td>slot_key</td>
<td>int</td>
<td>4</td>
<td>Slot key if tape inserted in drive</td>
</tr>
<tr>
<td>drive_num</td>
<td>short</td>
<td>2</td>
<td>Drive number (0-4)</td>
</tr>
</tbody>
</table>

#### Jukeslot

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>slot_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key for each Jukebox slot</td>
</tr>
<tr>
<td>juke_key</td>
<td>int</td>
<td>4</td>
<td>Jukebox the slot is in</td>
</tr>
<tr>
<td>position</td>
<td>short</td>
<td>2</td>
<td>Position of the slot (1-144)</td>
</tr>
<tr>
<td>type</td>
<td>short</td>
<td>2</td>
<td>Type of tape in slot (0/1/2/3/4 = empty/RInew/RI/clean/other)</td>
</tr>
<tr>
<td>tape_key</td>
<td>int</td>
<td>4</td>
<td>If type = RI, this is the tape_key for the tape</td>
</tr>
<tr>
<td>arc_key</td>
<td>int</td>
<td>4</td>
<td>The arc_key of the tape (If type = RInew or RI)</td>
</tr>
<tr>
<td>tape_no</td>
<td>int</td>
<td>4</td>
<td>The tape number of the tape (If type = RInew or RI)</td>
</tr>
<tr>
<td>in_jdrv</td>
<td>int</td>
<td>4</td>
<td>Which jukebox drive is the tape in (if not in slot)</td>
</tr>
</tbody>
</table>

#### Juketapeset

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key of Supported tapesets on Jukedrives</td>
</tr>
<tr>
<td>arc_key</td>
<td>int</td>
<td>4</td>
<td>Link to archive table</td>
</tr>
<tr>
<td>jdrv_key</td>
<td>int</td>
<td>4</td>
<td>Link to jukedrive table</td>
</tr>
<tr>
<td>juke_key</td>
<td>int</td>
<td>4</td>
<td>Link to jukebox</td>
</tr>
</tbody>
</table>

#### Jukequeue

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key</td>
</tr>
<tr>
<td>juke_key</td>
<td>int</td>
<td>4</td>
<td>Key for Jukebox to archive on</td>
</tr>
<tr>
<td>type</td>
<td>short</td>
<td>2</td>
<td>Type (1/2/3 = Retrieve/Archive/Clean)</td>
</tr>
<tr>
<td>priority</td>
<td>short</td>
<td>2</td>
<td>Priority of queue item (0-9)</td>
</tr>
<tr>
<td>examkey</td>
<td>int</td>
<td>4</td>
<td>Examkey of exam (or aexm_key if retrieve function)</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status of queue item (0/1/2 = Active/Ready/Error)</td>
</tr>
<tr>
<td>dir_key</td>
<td>int</td>
<td>4</td>
<td>Directory the exam is on (or directory to retrieve to)</td>
</tr>
<tr>
<td>arc_key</td>
<td>int</td>
<td>4</td>
<td>Archive to use for archiving and retrieving</td>
</tr>
<tr>
<td>auto_remove</td>
<td>short</td>
<td>2</td>
<td>Remove exam after archiving (1=Yes)</td>
</tr>
<tr>
<td>retrv_cmd</td>
<td>char</td>
<td>256</td>
<td>Command to execute after archiving or restoring an exam</td>
</tr>
<tr>
<td>ins_time</td>
<td>datetime</td>
<td>8</td>
<td>Time item was inserted into the queue (for statistics calcs)</td>
</tr>
</tbody>
</table>

#### Modem

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mdm_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key</td>
</tr>
<tr>
<td>portspeed</td>
<td>int</td>
<td>4</td>
<td>Speed of the computer port to set (&gt; modemspeed)</td>
</tr>
<tr>
<td>modemspeed</td>
<td>int</td>
<td>4</td>
<td>Modem speed in bits per second (eg: 28800)</td>
</tr>
<tr>
<td>host_key</td>
<td>int</td>
<td>4</td>
<td>Host key of workstation the modem is on</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status (0/1/2/15 = Ready/Busy/Error … out of service)</td>
</tr>
<tr>
<td>alias</td>
<td>char</td>
<td>32</td>
<td>Name of modem to be used in menus</td>
</tr>
<tr>
<td>device</td>
<td>char</td>
<td>16</td>
<td>Device name (eg: /dev/cua/a)</td>
</tr>
</tbody>
</table>
8. areacode char 16 Area code of modem phone number
9. phonenum char 16 Modem phone number
10. dir char 64 Directory to store temporary images (/img/ftp)
11. prefix char 16 Prefix if required to dial out ("9," if necessary)
12. longdist char 16 Prefix to dial if long distance (1)
13. next_mdm int 4 Next modem to use if this one is busy

**Modemqueue**
1. queue_key serial 4 unique sequential key for each queue item
2. mdm_key int 4 Modem to use for this transmission
3. priority short 2 Priority to handle this item (0-9)
4. status short 2 Status of this item (0/1/2 = Active/Ready/Error)
5. send_dir char 64 Directory to use for temporary storage during sending
6. phone_key int 4 Phone directory to use for sending this data
7. useralias char 32 Alias for User receiving this data
8. entry_time datetime 8 Time of entry into the queue
9. last_time datetime 8 Last time the transmission was attempted
10. delay_time short 2 Delay time (time between retries)
11. max_retry short 2 Maximum number of retry events
12. cur_try short 2 Number of the current retry.
13. remove short 2 Remove data after transmission (1=Yes)
14. descr char 64 Description of the transmission (errors included)

**Sortarc**
1. sort_key serial 4 unique sequential key for Archive list sorting
2. priority short 2 Priority in menu (order in menu)
3. descr char 16 Description of the sort item (Name, Location..)
4. sorttext char 64 SQL sort text to sort the list by
5. user_key int 4 If applicable to only 1 user, include user_key here

**Sortpat**
1. sort_key serial 4 unique sequential key for Patient List sorting
2. priority short 2 Priority in menu (order in menu)
3. descr char 16 Description of the sort item (Name, Location..)
4. sorttext char 64 SQL sort text to sort the list by
5. user_key int 4 If applicable to only 1 user, include user_key here

**Sortimg**
1. sort_key serial 4 unique sequential key for Image List sorting
2. priority short 2 Priority in menu (order in menu)
3. descr char 16 Description of the sort item (Name, Location..)
4. sorttext char 64 SQL sort text to sort the list by
5. user_key int 4 If applicable to only 1 user, include user_key here

**ISTdefaults**
1. param serial 4 unique sequential key for Image List sorting
2. descr char 32 Description of default item
3. value int 4 Integer value of numeric item
4. cvalue char 64 Character value of ascii item

### D. DISK SPACE REQUIREMENTS

The disk space used by the database can be separated into static and dynamic components. The static component consists of the programs, data structure and system tables required to operate the database functions. This component will occupy nearly the same amount of disk space no matter how many patient exams are added to the database. The dynamic component consists of information that is inserted into the various tables to allow access to patient demographics, exam, series and image information. The dynamic component also consists of
the archive component of the database which will allow an operator to search for a desired patient to retrieve it from the tape archive.

**Static Component**

The static or system component consists of the informix program structure in the "/home/informix" directory, and the fixed structure of the actual exam and user login databases. The informix directory occupies approximately 7 MBytes of disk space on the database server when fully configured. The structural components of the exam, user login and system tables require approximately 1 MByte. This space will be used even if no patient exams exist in the database. Therefore, a minimum of 8 MBytes should be allocated to handle the static components on the database server.

**Dynamic Component**

The disk space used by the dynamic component varies depending upon the system usage and can be broken into two main segments: the patient exams which currently exist within the system on hard disk (on-line), and the archived exams which exist on tape. Of these, the on-line exams require disk space for each image file and for the information added to the database tables for demographic and exam information (exam tables). The archived exams occupy disk space for the information required to locate the exam in the future (archive tables).

**On-line exams**

The disk space requirements can be calculated for the on-line exams by estimating the average number of exams acquired per day and the number of days these exams will exist within the system before being archived. The following information may be used as an example for this calculation:

- **20** exams per day on each scanner
- **3** scanners used
- Remain on the system for **2** days
- Each exam has approx. **4** series with **25** images in each
- Each image is 256x256x16 or **0.15** MBytes with header

\[
\text{20*3*2*25*4*0.15} = 1,800 \text{ MBytes or 1.8 GBytes for the images}
\]

- Patient table occupies **51** bytes
- Exam table occupies **124** bytes
- Series table occupies **38** bytes
- Image table occupies **122** bytes

\[
\text{20*3*2*(51+124) = 21 kBytes for the patient information}
\]

\[
\text{20*3*2*4*38 = 18.2 kBytes for the series information}
\]

\[
\text{20*3*2*25*4*122 = 1,464.0 kBytes for the image information}
\]

The total database space for the on-line demographic information is **1.5 MBytes**, much less than the 1,800 MBytes required for the images. Hence the images are spread throughout the system in a distributed fashion, and may reside on any of the available disks. The 1.5 MBytes required for the patient information must be available in the database disk partition on the server.

**Archived exams**

The disk space requirements can be calculated for the on-line exams by estimating the average number of exams acquired per day and the number of days these exams will exist within the system before being archived. The following information may be used as an example for this calculation:
20 exams per day on each scanner
3 scanners used
  scan 5 days per week
  open 52 weeks per year
  maintain archived information for 7 years
20*3*5*52*7 = 109,200 exams over 7 years
  Each tape holds approx 200 exams
  Tape table occupies 22 bytes
  ArcExam table occupies 85 bytes
20*3*5*52*7/200*22 = 12 kBytes for the Tape information
20*3*5*52*7*85 = 9,282 kBytes for the ArcExam information
The database space requirements to maintain the patient archive information for 7 years for this facility is only 9.3 MBytes.

**Database Partition - Disk Space**

Therefore, the total database disk requirements, now allowing for duplicate exam archives and non-database related files is only 8+1.5+9.3+9.3 = **28.1 MBytes**. The database will function properly as long as there is sufficient disk space to store the information. If the disk space is allocated on a partition where users are also storing files, or on an image partition where too many images may be stored, then the available disk space will be insufficient to store this information and database contamination may occur. It is therefore recommended to create a separate data partition on the database server with VERY conservative space allocation estimates. This will minimize the chances of database corruption. You should also check the space on a regular basis (at least once a month) to make sure that sufficient disk space exists. Even if you are very conservative and allocate a great deal of space, many times your network will expand and your initial assumptions will become invalid.

A scheduled program on each database server was designed to warn the system administrator if the disk space on the database partition goes below a selected value. The installation manual discusses the use of the application. It is recommended to have the system warn you if the partition drops below 10 MBytes to start with. If this should occur, you can always lower the limit until you have time to allocate more space.

**Archive Database - Tape Requirements**

To store the 7 years of patient images from this facility on tape, you would only need 109,200/200 = 546 tapes. At the current cost of $12/tape, the total cost to archive this information is only $6,552, quite a reduction from film storage costs or alternative archive methods. The storage space is also considerably reduced compared to film requiring only a small bookcase.

**E. Updating System Information**

UNIX script programs have been provided to simplify system maintenance and upgrades. These programs allow the system administrator to list, add, and delete various attributes of the system such as printers, scanners, users and image directories. **Use caution when changing the system information, as incorrect modifications may prevent the normal operation of the system.** Consult the installation manual for further details regarding these programs.
V. Image Import/Export

RI'port was designed to import images from remote scanners or export images to these same scanners via ethernet network protocols. Image transfer of this type retains true digital image accuracy and header information throughout the system, no matter how many times the images are transferred. Furthermore, in comparison to video frame grab technology, digital image transfer offers many advantages: 1) entry of patient demographics does not need to be duplicated, reducing time and error, 2) it does not degrade or limit the image information, 3) it maintains the full 16 bit image intensity range for subsequent window and level adjustment, 4) the images may be returned to the scanner in their original format justifying the use of Rational Imaging's system as a centralized archiving node, and 5) quantitative analysis becomes possible since the header information and exact digital intensities are replicated within Rational Imaging's system.

The images are selected from the source device and transferred to the destination device. The import function will transfer images from remote scanners to a selected SUN workstation for processing and review. The export function will send archived or new images back to selected remote scanners for filming or further analysis. New image communication technology may even allow sending the images from the scanners to the SUN workstations. These features will depend on the manufacturer of the scanner as to the exact functions available.

Once the images have been imported into the RI system, the images may be accessed by any of the SUN computers using the associated image display and processing programs. An important feature of this system is that these workstations may be located locally or remotely via Wide Area Network technology (Microwave, ISDN, T1, Satellite....). This allows versatile filmless review to be performed from virtually anywhere.

A. SOURCE AND DESTINATION MENUS

Select the source and destination devices by clicking on the menu triangle next to the prompt. Alternatively, the menu can be displayed for each prompt by pressing the right mouse button (menu button) over the menu triangle. Use the right mouse button again to select from the menu. The RI database maintains information regarding the network location, manufacturer, and image type for each of the scanners.
The source can not equal the destination, and the program can not copy images between remote devices without first importing the images to the SUN workstation. Images may be copied from one SUN workstation to another, however there is little need to do this since once the images are in the Rational Imaging network, all of the software can access them. There may be a need to move images off of a particular system if disk space becomes limited or if system maintenance is required.

B. Patient Selection Popup

Click the Select Patient button to display a list of patient's on the selected source device.

List Patients Button

Click on the List Patients button with the left mouse button to list the exams on the selected source device. This list will vary slightly depending upon the type and manufacturer of the scanner. However enough patient and exam information will be displayed to select an exam for transfer. If the accept button is pressed after selecting a patient's exam, then the entire exam will be imported into the RI system. The sort options will work for the local device, however sorting may not work for all of the scanners due to the limited capacity of the scanner's inherent image database.

List Series Button

To transfer individual series, first select the desired exam, then press the list series button. Information pertaining to each series will be displayed in the scroll list. Use the scroll bar on the right side to move between pages of information. Use the left mouse button to select the series for transfer. Individual series or image transfer IS NOT RECOMMENDED since there will be no way of knowing later which exams have only been partially transferred.

List Images Button

To transfer individual images, first select the desired series, then press the list images button. Information pertaining to each image will be displayed in the scroll list. Use the scroll bar to page through the information. Then select the images for transfer.

Diag View/Tech View selection

The diag view/tech view button allows the operator to select from two different views of the patient stored information. The Diag view has a more generalized listing of information including referring physician. The Tech view presents the status of the records in a number of different categories.
Compression

The compression option will apply lossless compression to exams transferred between Sun workstations to improve the transfer rate. A 2:1 compression can be obtained with this option. This will help transfers over low-bandwidth lines (ISDN for example), however it will only increase the transfer time over normal networks (10/100baseT) due to the overhead involved in the compression/decompression algorithms. This option does not affect transfers between scanners and the Sun workstations if the scanners do not support the compression.

Sort Options

The exam and image information may be sorted in the scroll list. The exam information may be sorted by patient name, exam number and exam location. These options are useful to locate a particular patient (name sort), verify that all of the exams have been received from a particular scanner (exam sort), or determine the patient exams on a particular system (location sort).

The image information may be sorted by image number, echo time (TE), time of acquisition or QRS, or descending image number.

These sort options will work for a local device, however it may not work for all of the scanners.

Exam/Series/Image Scroll List

This scroll list displays information from the selected source device. The information will vary depending upon the device and the requested information. Selection of items within this list is accomplished by toggling the items on or off with the left mouse button. A scroll list menu is also available by clicking the right mouse button over the scroll list. This will provide additional selection functions. The operational aspects of scroll lists are defined in more detail in chapter II: Graphical User Interface.

Scroll List Menu

For additional selection functions, press the right mouse button over the scroll list to display the scroll list menu. This menu will allow you to select or clear all of the items in the scroll list. Additionally, it will allow you to match several parameters to select similar items. For example, to select all of the MR images with the same echo time, first select one of the images with the desired echo time, then select the "match TE" option from the scroll list menu.

Transfer Button

Press the Transfer button to begin the transfer to or from the scanners. If the images already exist on the local SUN workstation, the RI'port window status bar will show that these images already exist and RI'port not overwrite them. If these images exist on a remote scanner, then an error will occur and a warning will be issued. RI'port will continue transferring all of the selected images, series and patients unless a fatal error occurs (i.e.: out of disk space, ethernet transmission errors, power cord is pulled out...).

As each image is transferred, the current image information will be displayed in the status bar located on the lower right corner of the RI'port main window (footer). The transfer rate of MR images is approximately 1 image per second. This transfer rate is generally limited by the scanner itself, and not the ethernet. When the scanner is reconstructing images,
scanning a new protocol or doing disk functions, the transfer rate and network response may deteriorate slightly.

**Transfer and Quit Button**

The Transfer and Quit button performs the same function as the Transfer Button, however the program will quit automatically when the transfer has completed. This will relinquish memory for other applications. Since it is advisable to conserve system memory, it is recommended to use this button rather than the transfer button.

### C. Disk Space Guages

The destination selection will determine which host computer the images will be imported to. The images will be put on the image partition with the greatest disk space to provide load-balancing on the destination.

When RI'port is run from a RI workstation, the images are transferred from the scanner to that workstation, and then to the disk. If the disk is located on that workstation, then there is only one ethernet transfer involved. If however, the disk was selected from another system, then the images would have to come from the scanner to the workstation running RI'port, and then go over the network to the remote workstation. This would require two network transfers and therefore a warning is issued in that event. RI'port should be run from the workstation that has the desired disk. Only the disk locations on the system running RI'port will be available as destination locations. Additionally, if you are exporting an exam to a scanner, RI'port should be run on the workstation containing that exam. The patient selection scroll list shows the exam information and image locations.

This is not a limitation however, since RI'port can be run remotely from another workstation. During the installation, each RI workstation will be added to the host table and can be selected using RI'login. Simply select the desired remote workstation from the "Run on host:" option on the RI'login interface and then run RI'port. The system may prompt you to confirm remote operation of RI'port. Select Yes to confirm your selection. When riport is run remotely, the name of the workstation appears in the title bar of the RI'port main window. Use this information to confirm the location of RI'port. These options, although a little confusing, will dramatically improve network traffic and minimize the number of ethernet collisions on a busy network.

When the destination is selected, the corresponding disk space will be displayed in the colored rectangle. This rectangle will appear green if 500 or more images can be stored on the disk. The rectangle will change to yellow if less than 500 images may be stored and then red as the disk space falls below 250 images. The selected disk location will be used to store the images unless the images from the same exam already exist within the RI system. The RI database will intercede in this case and locate the newly selected images on the same disk as the previously imported images. If that disk is full, then the new images can not be imported unless the images for that exam are removed from the full disk or copied to another system. No warning is currently issued to tell the user that the images are being relocated. It is therefore recommended practice to transfer
all of the images and series from a particular exam at one time, such as immediately following the acquisition. This will ensure that the entire exam was transferred and will optimize network efficiency. It is also recommended practice to leave plenty of extra disk space on each workstation, since additional space is take up by the printing process and by temporary file storage required by some of the applications.

D. DRAG & DROP IMAGE IMPORT

Open Windows supports a drag-and-drop protocol which allows a file to be selected from the File Manager, and dropped into an appropriate function. For example, files may be dragged from the disk directories to the wastebasket, or into another directory. Similarly, the RI'port program allows the operator to drag images with defined header information into the sensitive drag-and-drop rectangle at the upper right corner of the RI'port window.

If the images are of known origin, then they will be imported into the database. This will allow users to import images into the database which have been retrieved from 9-track tape or from other origins.

To operate this function, select File Manager from the Programs Menu under the Workspace (Workspace Menu | Programs | File Manager). Locate the desired image or set of images by selecting the directories in the File Manager. Once the image has been located, drag the image file over the sensitive rectangle in the upper right corner of the RI'port window. The status bar will report the failure or the success of the import.

If multiple images are desired, use the select all function under the File Manager or multiple files may be selected by pressing the middle mouse button over the files. Once all of the files have been selected, drag the group of files over the drag-and-drop rectangle. The status bar will again report success or failure.

The list of supported image headers for drag and drop import is listed in the installation manual.

E. MULTITASKING ADVANTAGES

Since the RI workstation is multi-tasking, multiple programs may be run at the same time. For example, you may select multiple versions of RI'port to be run simultaneously. This will allow you to specify import or export options for several scanners at the same time. Or RI'port may be run from several remote workstations to facilitate transfer to separate locations.

F. RELIABILITY ISSUES

If the scanner or RI workstation should go down during image transfer, then any incomplete transfers can be identified using the patient scroll list in the RI'port program. At the onset of exam transfer, a completion flag is set to NO. When the entire exam or set of images is transferred, then this flag is returned to YES and the system integrity is maintained. If however, an act of God or similar event prevents the normal transfer of images, then RI'port will list the exam as INCOMPLETE. To clear this flag, simply complete the transfer of images for this patient from the scanner to the RI system.

RI'Store will also notify you if an exam is marked as incomplete. Do not archive incomplete exams as there may be missing images. NOTE: Riport can not tell if images sent from a scanner
have been interrupted, so pay attention to ALL warning and error messages on both the SUN workstation and the scanner’s console.

During normal use, RI'port may list some patients as INCOMPLETE, if in fact they are currently in the process of being transferred. Since the RI system is both multitasking and networked, the chances are highly likely that when you list the patients within RI'port, that somewhere else images are being transferred to or from a remote workstation.

**G. USER CUSTOMIZATION**

The config button allows the operator to save the current window layout. Each user can specify a separate location for their configuration files by setting the deflt_dir in the users table in rilognin.dbs. This way, each user can customize the locations and layout of the entire RI system. The config button also saves the various options for the program prompts in these configuration files. Therefore, the next time you run RI'port, it will return to these defaults. The configuration file for riport is ".riport4". The numeral 4 may be incremented reflecting various enhancements to the parameters contained within.

When the Rational Imaging system is first installed, every user is given the same default directory location. As you become experienced with the system, consult with your system administrator to have this changed so that you may customize your own environment. If you do so however, then some of the upgrades performed for the other users, will also have to be performed individually for your environment. Therefore, only customize this environment parameter if it is reasonably necessary. Consistency between the user accounts may be preferable to versatility.

**H. QUIT**

To quit RI'port, click on the quit button. Quitting in this fashion will ensure that all of the system facilities used by RI'port will be relinquished (memory, disk space, X-Window screens, etc).
VI. Components of Image Display

RI'view is the main application used to display and print diagnostic images. This chapter will describe in detail the operational components of RI'view. Use this chapter as a reference when subsequent chapters refer to these functional components, and also to become familiar with the upgrades and changes incorporated in each software upgrade.

Each section in this chapter is dedicated to one of the windows associated with the RI'view process. The main window is the first window of a program to be displayed, however as additional functionality is requested, other associated popup windows will be opened. This reduces the initial complexity of the program without limiting the versatility of the application. If you never print images, then you will never open the print options window or the Print Page window. If you never annotate images, then you will never see the text options window. Thus the application is tailored to display only those functions which you, the operator, require.

A. RI'VIEW MAIN WINDOW

The RI'view main window is activated by opening the RI'view icon or selecting RI'view from the Rational Imaging program launcher, RI'login.

Title Bar

The title bar will initially display the function of the application such as "Image Review" for RI'view or "Image Archive and Retrieve" for RI'store. In RI'view, the patient's name, ID number, and exam number will eventually be displayed in the title bar when the images are loaded and displayed.

Patient Selection Button

The patient selection button will open the patient selection popup. The first time the button is pressed, a list of patients will be displayed. If individual series for a selected patient are already loaded, then subsequent clicks on this button will only list the series relating to the selected patient.

Layout Button

The layout button allows the operator to apply pre-defined image preparation templates referred to as "load templates" to the new exam. These load templates control the layout of the images for optimal and consistent image display.
Tools Button

The tools button will display the tools popup if a patient exam is currently loaded. No action will occur if the patient exam has been closed and removed from memory. This button is only necessary if you have pulled the pushpin and closed the tools popup. Otherwise the tools popup is opened automatically when a patient's images are loaded.

Next Window Button

This button will cycle through all of the created windows. During a typical review process, multiple image display windows will appear on the screen. These image windows may, at times, overlap or completely cover another window. When one window is obscured by another window, it may be necessary to pull the pushpin on the top window to close it, or click on the next window button till the desired window appears. Only one of these windows is active, or selected, at a time. To change the active window, simply click the next window button. You may also click on the header, frame, or over an image within another window to make that window active.

Previous Window Button

Just to the right of this button is the Previous Window button. This button acts similarly only in the opposite direction.

Next Page Button

When an image window is displaying multiple images, it may not be able to display all of the images in the series without making the images too small for diagnostic purposes. Therefore, this button is used to display the next page of images within the window.

This button uses an overlap rule so that if possible, the last images on the page will appear at the top of the next page. The rule consists of moving the last row of a window to the top of the next page. If the window contains four rows, then the last row of images will be moved to the top of the next page and three more rows will be displayed in the window. If only one row is present, then this button will display the next page of images without overlap.

If the end of the series is currently being displayed, then clicking this button will display the images from the beginning of the series. The image number slider or the label image button can be used to determine the image numbers.

Previous Page Button

This button operates much like the next page button except that the previous page of images is displayed. It also has some overlap with the previous page.

Dictation Button

The dictation button will bring up a separate process to record audio information and link it to the patient exam. These application are under development, and will be available shortly.

Mail Button
The mail button will bring up the mail application with the patient demographics already inserted in the body of the mail text. This will improve the efficiency of sending status mail to referring physicians regarding a particular case.

**Reports Button**

The mail button will bring up an application to view the patient’s reports associated with the exam. These will appear in a filename list, and will be viewed when the user selects the file.

**Config Button**

The config button is used to open the config popup. During normal use this popup is not required. However, if you want to customize the default options within RI'view, then click on this button and change the desired options within the config popup.

**Save Button**

The save button opens the save layout popup. This button and its associated window are used to save the layout of the current exam and update various database information regarding any operations performed.

**Info Button**

The info button is used to display the information popup. This button is used to determine the current version of the RI'view program when reporting errors to technical support.

**Quit Button**

The quit button is used to close the currently loaded patient, release all database links, turn the in-use flag for the exam off, and exit the RI'view program. This will not iconify the program, but will remove it from memory completely. This is the suggested way to exit the RI'view program, however you can also exit using the window menu located over any of the borders of RI'view or over its icon.

**B. Patient Selection Popup**

The patient selection popup is used to display exam, series and image information in order to load the desired images for review. This popup is displayed by clicking on the select patient button in the main RI'view window. It will be closed automatically when the exam has been selected and the load patient exam button is clicked. It can also be closed by pulling the pushpin in the left upper corner.

**Exam/Series/Image Scroll List**

The scroll list present in this popup is used to display exam, series and image information. The column titles and specific information displayed changes depending upon whether a patient, series or image list was requested. For example, when the popup is first opened by clicking on the select patient button, the scroll list will display a list of patient exams.
currently in the RI system. You can select an exam by clicking with the left mouse button over the desired exam. With an exam selected, click on the list series button to display a list of series for the selected exam. Similarly, with a series selected, click on the list images button to display a list of images for the selected series.

Use the slider on the right hand border of the scroll list to step or page through the list of information. Refer to Chapter 2 (Graphical User Interface section) for more information on controlling scroll lists.

**Patient List Tabs**

On the left hand side of the patient list are tabs which can be used to limit the patient list based on database query criteria. These tabs can be used to list only MR or CT exams, or show only Knee or Abdominal exams. They can also be further customized by applying appropriate SQL database select commands in the riview tabs file located in the user’s defaults directory (/net/server/img/defaults/.riview_Q). This ascii file can be edited to create more custom patient list criteria. More tabs can be displayed using the up/down arrows. The maximum length of the SQL query entered into this file must not exceed 1024 characters.

**Exam/Image Sort Options**

Sort options exist for the exam and image lists. Since there are rarely more than 5 to 10 series within an exam, sorting of the series is of minimal utility. Click over the menu triangle next to the sort option with the left mouse button to advance the option. You may also press the right mouse button over the menu triangle to open the sort menu. Use the right mouse button again to select the desired option from the menu. To apply the sort, click again on the list patients button or list images button.

**Patient Query Button**

The query button opens the patient information popup when an exam is selected in the patient list. This button is used to display more specific information regarding the patient's exam and operational information. See page VI-5 for more information. Several exams may be queried by first selecting the exams and then pressing the query button to advance the exam information.

**Lock Exam Button**

The lock exam button allows the operator to lock or unlock selected exams. If the convention is to remove exams after 1 day, and you want to keep an exam on the system for a week, then lock it to prevent it from being removed. In a networked environment, it is impossible to notify everyone as to which exams should remain on the system. Therefore, this function allows the user to control the availability of the exam with little effort. It will be the responsibility of the person who locks an exam to remove the lock when they are done with the exam.

If another operator attempts to unlock an exam, they are first warned as to who locked the exam and forced to confirm the unlock function.

**Archived Exam Button**

The archived exam button will list any archived exams associated with the selected exam. It will list the matches by both patient name and medical record...
number (patient ID). It will also list exams which match only 1 of these two identifiers. This will help locate exams when typos prevent a perfect match to the name or ID.

**List Patients Button**

The list patients button updates the scroll list with a list of exams currently in the RI system. It will use the sort option located beneath the button to perform a sort of the exams.

**List Series Button**

The list series button displays a list of series for a selected exam. You must select an exam from the list of patient exams in the scroll list prior to clicking this button.

**List Images Button**

The list images button displays a list of images for a selected series. You must select a series from the list of series in the scroll list prior to clicking this button. The button will not be functional unless a series is selected. For example, if the patient exam list is currently active, then clicking the list images button will result in the warning "Select a series first...".

**Load Patient Exam Button**

The load patient exam button is used to load the selected exam, series and image information into memory for display and printing. This button will issue a warning if nothing is selected from the scroll list. If an exam is currently selected, then all of the series and images will be loaded for review. If several series are selected, or only a few images, then those selections will be loaded when the accept button is clicked.

Multiple exams can not be loaded into RI'view. To accomplish the display of several exams simultaneously, run multiple copies of RI'view, each displaying a separate exam.

**Load Print Page Button**

The load print page button is used to load only the print pages associated with the selected exam. This is useful when you merely want to reprint the print pages or review them with the referring physician.

**C. DISPLAY FORMAT POPUP**

The load template concept allows predefined window and image characteristics to be applied to the images when the template is selected. These formats are user configurable files that contain defaults which automatethe preparation of each exam. These formats dramatically reduce technologist or physician preparation time and improve the consistency of the image display.

You can create different load formats or templates for each type of exam. The load format is keyed to each series number and description, and therefore a load format file should be created for each acquisition protocol. For example, a brain MR contains a different number of series than an abdominal CT. Also the size of the images and default window and level values are quite different. Therefore, the customization of these files is an important step towards automatic image preparation.
The .riview_L file in the user’s defaults directory contains a list of the load formats that will be available in this menu. This is an ASCII file which can be edited and options added, sorted, or deleted to customize the menu. These options can also be updated by opening the configuration popup as discussed later in this chapter. The name of the load format is specified following the word “Format”. Each load format file must begin with ".ri" and end in ".lod". For example, if a ".riMR_knee.lod" file exists in the user's templates directory specifying the window layout of the MR knee exam, and if "Format MR_knee" exists in the .riview_L file in the user's home directory, then the option "MR_knee" will be added to the load format menu when RI’view is run. More information regarding the load template’s file structure can be obtained in the appendix.

If the exam has been saved previously, then the previously defined layout will override any selected format except for "IGNORE SAVED". If you select "IGNORE SAVED" from the load template menu, then the images will be loaded without any load format, and they can then be reformatted manually. This may be useful in the event that the configuration becomes corrupted or only a partial series has accidentally been saved.

**Save Current Load Format Button**

Click on this button to save the current exam layout as a “load template” for all future exams. This option will bring up another popup allowing you to further customize the descriptions of each of the windows/series.

The scroll window displays the current series information that will be saved in the load template file. During initial image display, the load template will try to match these series descriptions during the image load. If this fails, it will use the series number to match and format the images. If neither match can be found, the the default format (0) will be chosen. The load template file can be manually edited to make the default format appropriate for that modality (i.e., CT window/levels and layouts can be applied if this is a CT template).

To add or change the description applied to a series or window, simply select that series, enter a description into “Desc:”, and click on the “Change Description” button.

The **Rule for Match** options allow you to select the protocol used for matching the series with the load template format.

Click on the “**Save Template**” button to save the layout.

When loading an exam, click on the accept button if the correct match between the left series and the right template information has been identified (in brackets). If you want to have series 3 look more like template item 4, then click on series 3 on the left first, followed by clicking on the template item 4 on the right.

**Select User’s Templates Button**

Click on this button to use someone else’s load templates. This option was added to allow a resident who has prepared the case to easily use another radiologist’s templates by selecting the radiologist’s name from the popup. Since each user will create custom templates based
on the preferred style of diagnosis and image display, this is important for efficient diagnostic interpretation.

D. Patient Information Popup

The patient information popup displays information regarding the exam currently selected in the patient selection scroll list. This popup is activated by pressing the query button "?" in the patient selection popup. Detailed patient and exam information will be displayed for the selected exam.

This information is not only useful for obtaining more specific patient information, it also displays critical information as to the performance of specific operations such as review and archival. This information may be very useful in determining accountability several years after the exam was performed, archived, and again retrieved.

E. Tools Popup

The tools popup is automatically opened when a patient is loaded for review. It also may be opened by clicking the tools button in the main RI'view window. This popup contains icons which perform various image processing functions. Many of the options found in this popup are also available in the image menu opened by pressing the right mouse button over any of the displayed images.

Mouse Control Mode

The mouse control icons alter the function of the mouse when a given mode is selected. Only one mode can be active at a time. These mouse control icons are also available from the image menu by pressing the right mouse button over any image.

When a given mode is selected, the mouse functions available within the active image display window are shown in the RI'view status bar. Only the active window will display the colored cursor indicating the mouse's functions, for example, when the select mode is active, then the cursor will show a yellow hand, and when the view mode is active, then the cursor will resemble an eye. Thus, you will quickly learn which functions are available when each of the cursors is present without having to refer to the tools popup or the status bar.

When a modifier key is depressed, such as shift, control or the meta key (diamond), then the mouse functions will change to pseudo mouse modes and the status bar and cursor shape will reflect the current mouse functions. These modifier keys can be considered "quick keys" and used to temporarily enter another mouse mode to make quick adjustments such as selecting individual images or copying an image to the print page. The "pseudo" modes are very similar to the major mouse modes, and therefore the cursor shape will resemble the major mouse mode functions while these modifier keys are depressed.

The "pseudo" mouse functions are slightly different for each mode, so pay attention to the status bar and the cursor shape when these buttons are depressed.
The first three options (view, text, and print) are considered *visual* in nature, in that they control the review, annotation, and printing of the images. The latter four options (win/lev, clip, select, and pan) are considered *preparatory* in nature, as they are used to affect the layout and display characteristics of the images on the screen.

- **View1**: The view1 mode allows a physician to quickly scan through MR/CT/US images quickly. The left and middle button will increment and decrement the pages of images, while dragging the mouse will rapidly scan through the images. In order to produce a rapid cine motion, the images need to be copied into high speed memory (see page VI-5). This is done automatically if the auto prepare mode was selected in the patient selection popup. If the fast load option was selected, then the images must be displayed at least once after zooming or adjusting the window/level to prepare the high speed memory. Once all of the images in the series have been displayed, then rapid scanning will occur. During the automatic preparation, the status bar will show "*Preparing high speed memory*".

The display has been designed to display multi-echo MR sequences side by side while scanning rapidly through the images. This can be accomplished by creating a window with two columns and one row displaying both images side by side. Then, when the mouse is dragged over the image window, the page of images will be incremented or decremented producing a side by side cine display. Even three or four echo sequences can be viewed in this manner by selecting three and four columns respectively. Cardiac-MR acquisitions having 4-12 slice locations can even be displayed in this manner, although the speed of the display will slow down with the number of images in the multi-image display.

In view mode, the image display will stop when the beginning or end of the series is reached. It will not continuously loop forward or backwards like the cine display.

The cursor will resemble an *eye* when this mode is selected. The following mouse buttons are operational over the active image window as shown by the RI'view status bar:

<table>
<thead>
<tr>
<th>L:pg+ M:pg- Shift:text Ctrl:print &lt;&gt;:zoom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left</strong>: By clicking the left mouse button over the image window, the page of images is incremented. If you depress the left mouse button over the image and drag the cursor, you can scan forwards and backwards through the images. By moving the mouse vertically (up or down), you can increment or decrement the page of images respectively. If you move the mouse horizontally (right or left), you can also increment or decrement the page of images respectively. Any diagonal movement will produce a combined effect.</td>
</tr>
<tr>
<td><strong>Middle</strong>: By clicking the middle mouse button over the image window, the page of images will be decremented.</td>
</tr>
<tr>
<td><strong>Shift</strong>: If the shift key is depressed, then the mouse mode will resemble the text mode. Arrows can be drawn and text can be moved in this mode. The mouse cursor will display a <em>pencil</em>.</td>
</tr>
<tr>
<td><strong>Control</strong>: If the control key is depressed, then the mouse functions will emulate the print mouse mode. The left mouse button can copy individual images from the active window to the print page, and the middle mouse button will create multiple print pages with all of the images in the selected series. The cursor will display a <em>printer</em> while the control key is depressed.</td>
</tr>
</tbody>
</table>
**Meta (♦):** If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor will display a *magnifying glass*.

The following functions are available over the print page window as shown by the status bar:

**Shift: zoom  Ctrl: select**

**Shift:** The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a *magnifying glass*.

**Control:** If the control key is depressed, then the mouse functions will change to emulate the *select* mouse mode allowing you to select individual images.

- **View2:** The view2 mode allows a physician to manipulate and optimize a large Xray or DR image easily. The left mouse button will adjust the window/level (brightness and contrast). The middle button will display a magnifying glass over the image enhancing the high-frequency content of the image.

The cursor will resemble an *eye* when this mode is selected. The following mouse buttons are operational over the active image window as shown by the RI'view status bar:

**L: winlev  M: zoom  Dbl: reset  Shift: text  Ctrl: print**

**Left:** By dragging the left mouse button over the image window, the window/level of the image can be adjusted. Left / right motions affect the contrast, and up / down motions affect the brightness.

**Middle:** Holding down the middle mouse button will display a magnifying glass over that portion of the image to bring out the fine detail in the image.

**Dbl:** If the left mouse button is double-clicked, the image intensity will be reset to the maximum range of intensities in the image.

**Shift:** If the shift key is depressed, then the mouse mode will resemble the text mode. Arrows can be drawn and text can be moved in this mode. The mouse cursor will display a *pencil*.

**Control:** If the control key is depressed, then the mouse functions will emulate the print mouse mode. The left mouse button can copy individual images from the active window to the print page, and the middle mouse button will create multiple print pages with all of the images in the selected series. The cursor will display a *printer* while the control key is depressed.

The following functions are available over the print page window as shown by the status bar:

**Shift: zoom  Ctrl: select**

**Shift:** The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by
Chapter 6. Components of Image Display

5.3.01

VI-10

this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a magnifying glass.

Control: If the control key is depressed, then the mouse functions will change to emulate the select mouse mode allowing you to select individual images.

• Text: The text mode allows annotation and arrows to be added to the image display while reviewing the series of images. The cursor will resemble a pencil when this mode is selected and the text popup will appear as described on page VI-24. The following functions are operational over the active image window during this mode:

<table>
<thead>
<tr>
<th>L: text</th>
<th>M: color</th>
<th>Dbl: delete</th>
<th>Ctrl: print</th>
<th>&lt;&gt;: zoom</th>
</tr>
</thead>
</table>

Left: The left mouse button can be used to drag out an arrow. Position the cursor over the image where the head of the arrow should occur, then drag out from that spot to orient the arrow correctly. Release the mouse button when the arrow is correctly positioned. To move the arrow, place the cursor over the head of the arrow and drag the arrow to a new location. The left mouse button is also used to determine the lower left hand corner of text to be entered on the image. You can select multiple lines of text or arrows by clicking over them with the left mouse button. You can then drag all of the items together or delete them using the double click. Other options other than text and arrows are available in the text popup described starting on page VI-24.

Middle: You can unselect any selected items by clicking on the middle mouse button over the desired image.

Double click: You can delete text or arrows by positioning the cursor over the text or the head of an arrow and double clicking the left mouse button. If multiple items are selected, then all of the selected items will be deleted.

Control: If the control key is depressed, then the mouse functions will emulate the print mouse mode. The left mouse button can copy individual images from the active window to the print page, and the middle mouse button will create multiple print pages with all of the images in the selected series. The cursor will display a printer while the control key is depressed.

Meta (♦): If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will display a magnifying glass.

The following functions are available over the print page window as shown by the print options status bar:

<table>
<thead>
<tr>
<th>L: text</th>
<th>M: color</th>
<th>Dbl: delete</th>
<th>Shift: zoom</th>
<th>Ctrl: select</th>
</tr>
</thead>
</table>

Left: By clicking the left mouse button over the print image, you are determining the location to begin typing text. The size and color of the text will be determined in the text options popup. Once the text is typed, you can drag it to another location using the left mouse button. You can create an arrow by dragging outward from the head of the arrow. You can also select multiple arrows or text to move or delete as a group by clicking over these items with the left mouse button. Click anywhere over the text to select it. Click near the head of an arrow to select it. Warning: the text and arrows on the print page are not linked to any image locations,
therefore adjust the size and location of the images by clipping and rearranging prior to adding text and arrows.

**Middle:** Click the middle mouse button to unselect any selected text.

**Double Click:** Double click over the desired item to delete it from the print page.

**Shift:** The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a *magnifying glass*.

**Control:** If the control key is depressed, then the mouse functions will change to emulate the *select* mouse mode allowing you to select individual images.

- **Print:** The print mode allows you to select images to fill the available image positions of the current print page. The images will be copied into the next available positions in the print page window and can be rearranged later by dragging the images to their desired locations. When the print mode is selected, the print popup will be displayed offering additional functions described starting on page VI-27. The cursor will resemble a *printer* when this mode is selected. The following mouse functions are operational over the active image window as shown by the RI*view status bar:

```
L:one M:all Shift:pg+ Ctrl:text <>:zoom
```

**Left:** If the left mouse button is clicked over an image, then that image will be copied into the next available position in the print page.

**Middle:** Click the middle mouse button over an image to create multiple print pages containing all of the images in the active print window. This will start by copying image #1 into the first available print location of the current print page and it will continue creating print pages until all of the images have been deposited in print pages. The print page created is specified in the print template field in the print options popup.

**Shift:** If the shift key is depressed, then the mouse functions will change to emulate the *view* mouse mode allowing you to page forward and backwards through the images. The cursor shape will resemble an *eye*.

**Control:** If the control key is depressed, then the mouse mode will resemble the *text* mode. Arrows can be drawn and text can be moved in this mode. The mouse cursor will display a *pencil*.

**Meta (⋄):** If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will display a *magnifying glass*.

The following functions are available over the print page window as shown by the print options status bar:

```
L:exchange M:copy Dbl:delete Shift:zoom Ctrl:select
```

**Left:** By dragging an image with the left mouse button depressed from one image location to another, you can exchange any two images.
Middle: By dragging an image with the middle mouse button depressed from one image location to another, you can copy an image to a new location.

Double Click: Double click over the desired image to delete it from the print page.

Shift: The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a magnifying glass.

Control: If the control key is depressed, then the mouse functions will change to emulate the select mouse mode allowing you to select individual images.

- Window/Level: This mode allows you to adjust the contrast (window) and brightness (level) of the selected images in the active window. Remember, if none of the images were individually selected, then all of the images are considered active or selected. During this mode, the active images will display the current window and level values with yellow text in a blue box over each selected image. While this mouse mode is selected, the Window/Level popup will appear allowing you to set exact window and level parameters. Click on the apply button in this popup to set the values you have entered. You may also set predefined window/level attributes by selecting these ranges from the apply menu. The values available in this menu can be optimized in the configuration popup described later in this chapter (page VI-32). Clicking on the window/level mouse mode control icon in the tools popup will set the current values in the window/level popup to those of the current image. You can then make another window active and click on the apply button to set the same window/level values in multiple windows. This is useful if you are comparing pre/post gadolinium for example. A more detailed description of the operation of this window can be found on page VI-32. The cursor will resemble a black/white circle when this mode is selected. The following mouse functions are available over the active image window as shown by the RI’view status bar:

  L:adjust M:invert D:reset Shift:pg+ Ctrl:select <>:zoom

Left: If you depress the left mouse button over the image and drag the cursor, you can adjust the window and level values. By moving the mouse vertically (up and down), you can adjust the level or brightness of the image. If you move the mouse horizontally (right and left), you can adjust the window or contrast of the image. Any diagonal movement will produce a combined effect.

Middle: Clicking on the middle button will invert the image intensities. White intensities will become black and vice-versa.

Double click: You can reset all of the image intensities to their original limits by double clicking over the active image window. This will affect only the selected images if any images are individually selected.

Shift: If the shift key is depressed, then the mouse functions will change to emulate the view mouse mode allowing you to page forward and backwards through the images. The cursor will display the eye icon.
Control: If the control key is depressed, then the mouse functions will change to emulate the *select* mouse mode allowing you to select individual or even/odd images. The cursor will display the *hand* icon.

Meta (♦): If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will be a *magnifying glass*.

The following functions are available over the print page window as shown by the status bar:

```
L: adjust M: invert Shift: zoom Ctrl: select
```

Left: If you depress the left mouse button over the image and drag the cursor, you can adjust the window and level values. By moving the mouse vertically (up and down), you can adjust the level or brightness of the image. If you move the mouse horizontally (right and left), you can adjust the window or contrast of the image. Any diagonal movement will produce a combined effect.

Middle: Clicking on the middle button will invert the image intensities. White intensities will become black and vise-versa.

Shift: The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a *magnifying glass*.

Control: If the control key is depressed, then the mouse functions will change to emulate the *select* mouse mode allowing you to select individual images.

**Regional Window/Level:** This mode allows the operator to apply a region for histogram/percent window/level analysis. Many times the periphery of the image contains non-diagnostic information which contains abnormally high or low image intensities due to a MR coil or the blanking circle of a reconstructed CT image. This mode allows the operator to select a central rectangle which will be used for image optimization during the application of a load template. This mode will not affect the current image, but it will improve the reliability of load template for certain types of exams. The following mouse buttons are operational over the active image window as shown by the RI'view status bar:

```
```

Left: the left mouse button is used to drag out a rectangular area for histogram analysis. When the left mouse button is released, the rectangle will be locked and the left mouse button can then reposition the rectangle.

Middle: the middle mouse button is used to accept the position and size of the rectangle. You will need to save the load template once this is done to preserve this setting.

Double Click: If you double click with the left mouse button, you can clear the rectangle allowing you to drag out another one.
Shift:  If the shift key is depressed, then the mouse functions will change to emulate the view mouse mode allowing you to page forward and backwards through the images. The cursor shape will display the eye.

Control:  If the control key is depressed, then the mouse functions will change to emulate the select mouse mode allowing you to select individual or even/odd images. The cursor shape will display the hand.

Meta (♦):  If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will display a magnifying glass.

The following functions are available over the print page window as shown by the status bar:

L: adjust/move  M: clip  Dbl: reset  Shift: zoom  Ctrl: select

Left: the left mouse button operates slightly different in the print page than in an image window. Each image in the print window can be clipped differently, and in fact, will be clipped separately unless similar images within the print page are selected using the select mode discussed in the next section. If multiple images are selected, then all the selected images will be affected by the clip command. If no images are selected in the print page, then only one image will be clipped at a time. Note also, that the clipping rectangle created will always have the aspect ratio of the image location you are clipping. If the print page has images which are different in width and height, be sure to drag out the rectangle over the image location you actually wish to clip.

Middle: the middle mouse button is used to accept the position and size of the rectangle and perform the clip.

Double Click: If you double click with the left mouse button, you can remove any clipping that is currently applied. If a yellow clipping rectangle is present, double clicking will clear the rectangle allowing you to drag out another one. This function will only affect the image under the cursor or the selected images if multiple images are selected.

Shift: The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a magnifying glass.

Control: If the control key is depressed, then the mouse functions will change to emulate the select mouse mode allowing you to select individual images.

Clip: The clip mode allows you to clip or crop the diagnostic portion of the image and remove non-diagnostic image information from the display. This conserves screen space which allows you to either enlarge the images or display more images on the screen. The cursor should resemble scissors while this mode is active. The following mouse buttons are operational over the active image window as shown by the RI’view status bar:

**Left:**  the left mouse button is used to drag out a rectangular area for clipping. When the left mouse button is released, the rectangle will be locked and the left mouse button can then reposition the rectangle.

**Middle:**  the middle mouse button is used to accept the position and size of the rectangle and perform the clip.

**DoubleClick:**  If you double click with the left mouse button, you can remove any clipping that is currently applied. If a yellow clipping rectangle is present, double clicking will clear the rectangle allowing you to drag out another one.

**Shift:**  If the shift key is depressed, then the mouse functions will change to emulate the view mouse mode allowing you to page forward and backwards through the images. The cursor shape will display the eye.

**Control:**  If the control key is depressed, then the mouse functions will change to emulate the select mouse mode allowing you to select individual or even/odd images. The cursor shape will display the hand.

**Meta (♦):**  If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will display a magnifying glass.

The following functions are available over the print page window as shown by the status bar:

```
L:adjust/move  M:clip  Dbl:reset  Shift:zoom  Ctrl:select
```
• **Select:** This mode allows you to select images for individual processing. For example, individual window and level values will need to be assigned to the images in a multi-echo MR series since the odd and even images have different image characteristics. Therefore, the select option was designed to give very versatile control over the images within a window. When an image is selected it is surrounded by a cyan rectangle. If no images have the cyan rectangle around them, then all of the images are considered selected (i.e., the processing options will be applied to all of the images). The cursor will resemble a **hand** when this mode is selected. The following mouse buttons are active over the image window as shown by the RIview status bar:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L:one</td>
<td>When you click the left mouse button over an image, you will select or unselect that image. Each selected image will have a cyan rectangle surrounding it.</td>
</tr>
<tr>
<td>M:even/odd</td>
<td>When the middle mouse button is clicked over an odd image, all of the odd images will be selected. When it is clicked over an even image, all of the even images will be selected. This button will select ONLY even and odd images. To select additional images or unselect some of the selected ones, use the left mouse button.</td>
</tr>
<tr>
<td>Dbl:reset</td>
<td>If you double click with the left mouse button, you can remove any image selection that is present. This is a quick way to deselect any selected images.</td>
</tr>
<tr>
<td>Shift:</td>
<td>If the shift key is depressed, then the mouse functions will change to emulate the <strong>view</strong> mouse mode allowing you to page forward and backwards through the images. The cursor shape will display the <strong>eye</strong>.</td>
</tr>
<tr>
<td>Ctrl:print</td>
<td>If the control key is depressed, then the mouse functions will change to emulate the <strong>print</strong> mouse mode allowing you to copy images to the print page. The cursor will resemble a <strong>printer</strong>.</td>
</tr>
<tr>
<td>Meta (♦):</td>
<td>If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will display a <strong>magnifying glass</strong>.</td>
</tr>
</tbody>
</table>

The following functions are available over the print page window as shown by the status bar:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L:one</td>
<td>When you click the left mouse button over an image, you will select or unselect that image. Each selected image will have a cyan rectangle surrounding it.</td>
</tr>
<tr>
<td>M:all</td>
<td>Double Click: If you double click with the left mouse button, you can remove any image selection that is present. This is a quick way to deselect any selected images.</td>
</tr>
<tr>
<td>Dbl:reset</td>
<td>Shift: The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a <strong>magnifying glass</strong>.</td>
</tr>
</tbody>
</table>
• **Pan:** This mode allows you to position clipped images within the borders of the image window. If the image is not clipped, then the entire image is already being displayed and this function will have no effect. This function will operate both in single and multi image mode panning all the image together. The cursor will resemble **arrows** when this mode is selected. The following mouse buttons are active over the image window as shown by the RI'view status bar:

**L:pan  Shift:pg+  Ctrl:print  <>:zoom**

**Left:** When you click the left mouse button over an image, you will select or unselect that image. Each selected image will have a cyan rectangle surrounding it.

**Shift:** If the shift key is depressed, then the mouse functions will change to emulate the *view* mouse mode allowing you to page forward and backwards through the images. The cursor shape will display the **eye**.

**Control:** If the control key is depressed, then the mouse functions will change to emulate the *print* mouse mode allowing you to copy images to the print page. The cursor will resemble a **printer**.

**Meta (♦):** If the meta key (diamond) is depressed, then the magnifying glass mode will be enabled. Move the cursor to different locations to magnify those regions and use the left and middle mouse buttons to increase or decrease the size of the magnified area respectively. The cursor shape will display a **magnifying glass**.

The following functions are available over the print page window as shown by the status bar:

**L:pan  Shift:zoom  Ctrl:select**

**Left:** The print images can be panned by dragging the left mouse button over the images. Multiple images can also be panned by selecting the images using the select function.

**Shift:** The shift modifier allows you to magnify or zoom each image. When you have the shift key depressed, each click of the middle mouse button over an image in the print page will magnify that image (or any selected images) by the factor set in the config window. Each additional click will increase the magnifications by this factor. If you press the left mouse button over a point of interest, that point will be magnified as you drag the mouse upward. The magnified point of interest will be centered around the initial selected position. This function will operate on multiple images if they are selected. The cursor will resemble a **magnifying glass**.

**Control:** If the control key is depressed, then the mouse functions will change to emulate the *select* mouse mode allowing you to select individual images.

**Split/Join (MultiImage) Button**

The split/join button splits the active image window into multiple images. Each click on this button increases the number of columns and rows by one. There is also a menu beneath this button which is available using the right mouse button. This menu will allow the user to select various layouts or control the columns or rows separately.

**Zoom Button**

The zoom button will allow you to adjust the magnification of an image. The menu beneath will set various magnification factors or fit the window to the current image if it has been stretched beyond the image borders.
Window Control Button with Menu

The window control button has a menu of functions that control the image window display. You can create, delete or hide image windows depending upon your preference. The following options are available in this menu:

- **Create image control window**: This option creates a window of thumbnails (1 for each series). The controls for the window allow the user to modify the image display from a centralized area (without having to scroll across multiple monitors).
- **Create duplicate window**: This option creates a new window containing only the selected images within the active image window. This is useful if you want to have two windows, one displaying a tissue equivalent CT image, and the other displaying the same image as a bone equivalent CT image. This is the default menu item if the left mouse button is clicked over this button. This is a powerful tool providing great flexibility to the image display.
- **Delete image control window**: This option deletes the image control window.
- **Delete duplicate window**: This option deletes the currently active image window if it is a duplicate window (designated by Copy appearing in the title of the window). This option will not delete original windows, although you can hide them using one of the other functions of this menu.
- **Display one at a time**: Since the workspace can become quite confusing with multiple windows displaying separate series, you may want RI'view to display only one image window at a time. When this option is active, only the currently active image window will remain on the workspace. The next window button (page VI-2) will close this window and open the next image window in the sequence. Thus, there will only be one image window at a time on the screen. Use display hidden windows to cancel this mode.
- **Hide current window**: This option will hide the active window. The next window button will not display any hidden windows. This option is never active whenever a new patient is loaded. It only becomes active through this menu. This is different than pulling the pushpin, because the window will not be displayed using the next window button as long as it remains hidden. Use the display hidden windows option to cancel this mode.
- **Display hidden windows**: Use this option to display all of the image windows and cancel the previous two options.

Undo Button with Menu

The undo button is used to remove any clipping, zoom, or window split from the active image window. There is a menu associated with this button which contains the following options. It can be displayed by clicking over this button with the right mouse button. Then select the desired option from the menu with the right mouse button.

- **undo all**: remove clipping, zoom and split image display from the active image window. This is the default menu option.
Chapter 6. Components of Image Display

- **undo clip**: remove clipping from the active window. Retain the multi-image window and the current zoom factor.
- **undo zoom**: remove any image zoom and display the images at their inherent resolution (Magnification = 1). Retain the multi-image window and the current clipping. When this is applied, the images can be displayed and manipulated much more quickly since the bi-cubic interpolation for floating point magnification does not need to be applied.
- **undo split**: remove window splits and display one image in the active window. Retain any zoom or clip specified.

**Monitor Button**

The monitor button, by right clicking with the mouse, allows you to select the desired monitor (screen) for the active image window. This button will relocate the active window to the desired screen. The remote option will allow you to select another host to simultaneously display the active image windows for consultations.

**Group image windows**

Click on this button to group similar image windows. When this function is active, all image planes that are parallel and have the same image locations will be grouped together. This allows pre and post contrast-agent images to be displayed together. It also allows CT images with multiple duplicate windows for bone and tissue equivalent settings to be displayed together. When a border of red surrounds the image, the planes are within 1 image thickness. When the red disappears, it means that the planes are not close together even though they may be parallel.

**Rotate Button**

The rotate button has a menu which allows the user to rotate the image to a desired orientation. This button can also be used to flip the image or apply a mirror transform (switch right and left).

**Image Sorting Options**

The Image Sorting Options button allows you to select the field used to sort the active images. The options available are Image, Location, Mr Echo, Time, Number Descending, and Loc Desc. Selecting Image will organize the images by increasing image number. Location organizes the images by increasing image location, then TE. Mr Echo organizes the images by increasing TE then Location. Time organizes the images by time (QRS) then by location. Number Descending is identical to the Image sort except in descending order. Finally, Loc Desc. Organizes the images just like the Location option except in descending order.

**Prior/Next Window/Level Button**

The left arrow will display the prior window/level setting, and the right arrow will display the next window/level settings. These are primarily used for CT images where bone/tissue/liver windows are applied to the same series. Clicking on these buttons will toggle between the predefined intensity settings for a particular image window.
Cross-Reference Button

Click on this button to activate the cross-reference display. When this button is clicked, the active window will be cross-referenced against all the other intersecting images. As the image in the active window is incremented or decremented, the intersecting windows will show a cyan line at the point of intersection of the two planes. If a line is not present, then either the image planes are parallel, they do not intersect within the displayed image region, or there is insufficient information in the image headers to determine cross-sectional intersections.

The cross-reference function is a toggle function, so just click on this button to turn this function off again. This is very useful for oblique acquisitions as well as for musculoskeletal imaging.

Cine Display Control

The following functions initiate the cine mode of the display. These are similar to VCR functions as described below.

- **Stop**: The stop button will stop any active cine display. It will reset the speed slider on the main RI’view window to 0.
- **End-Reverse**: The end-reverse button will initiate the cine display in a "spatial rotation" mode. The images will be displayed in ascending order until the end is reached, then the display will reverse and the images will be displayed in descending order. At each image extreme, the image display will change direction thus looping back and forth through the images.
- **Reverse**: The reverse button will initiate the cine display and set the speed to the default value specified in the config popup. The images will be displayed in descending order until they reach the beginning, at which point they will loop to the end. Adjust the default speed for reviewing cine displays in the config popup to a value you are comfortable with. Remember, you can easily alter the speed by adjusting the value on the speed slider of the main RI’view window.
- **Forward**: The forward button will initiate forward cine display. The images will be displayed in ascending order until the end is reached, at which time the display will start with the first image again.
- **Image Slider**: The image number slider displays the starting image number for the selected or "active" window. For example, if 5 is present on this slider and the window has 3 rows and 2 columns, then images 5 through 10 are being displayed. This is used for quick reference, or to quickly display a particular image. You may click on the label image button in the tools popup to confirm each image number. You may adjust the image numbers by dragging the control box, clicking on the cable to the right or left of this box, or entering a numeric value from the keyboard.
Chapter 6. Components of Image Display

- **Speed Slider:** The speed slider is used to select or change the cine display speed. During cine display, the pages of a window will be cycled at the speed displayed here (frames per second). Depending on the size of the image, the number of images being displayed, the number of background processes, and the power of your SparcStation, the maximum rate of 30 frames per second may or may not be attainable. To stop the cine display, simply select a display rate of 0.

- **Image/Series Selection:** If image is selected, then only the images within the active window will be displayed. If series is selected, then the cine operation will loop through all the images in each of the series or windows.

- **Minute/Second Selection:** This option controls the frames/time of the display rate where time is in seconds or minutes. The minute selection will be much slower than the second option.

### Label Images Button

Click on this button to activate the image labels. Image number, slice location, window/level, and RAS (right, anterior, superior) can be added to the image windows by selecting this function. Select the desired labels in the configuration popup as described on page VI-34. If this button is toggled one more time, ALL of the patient demographic information will appear on the images. A final toggle will again turn off the display of anatomic information. The format, color, and content of demographic information is controlled by a default file “.riview_D” in the user’s defaults directory. This will allow a facility to control the color, position and content of the display to match another system or user’s preferences.

The RAS information will display the orientation of the image plane (axial, sagittal, coronal, or oblique). The right/left (R), anterior/posterior (A), and superior/inferior (S) information is also given. For oblique planes, several letters may be given with the uppercase letter representing the major axis, and the lowercase letter representing the minor axis. For example if the cross-reference images shown below, the left side of Series #3 window is labeled **Rp** (right posterior), and the orientation is **OblCor** (oblique coronal). This suggests that the left edge of the image is right side of the patient and slightly posterior. If the oblique orientation were more posterior, then the orientation may change to **OblSag** (oblique sagittal) with the left edge displaying **Pr** (posterior right).

### Mask Subtraction Button

The mask subtraction button subtracts the mask from each displayed image. The mask is selected as the first image, or the sum of the images up to the currently displayed image when the mask subtraction button is clicked. For angiography, many times 1 or 2 frames is sufficient to form the mask, however in cardiology many times 30 or 60 frames is required to average out the cardiac motion.
Sharpen Image Button

The sharpen image button applies a high pass filter to the images, thereby sharpening the edges of the image and making them more apparent. The degree of sharpening applied can be selected in the config popup and is configurable for each individual user. This function is useful for enhancing the small trebecular structure of CT images displayed through bone windows. Unfortunately, noise is also enhanced by these filters, so you will need to decide on the strength of the filter to enhance the structural edges without over-enhancing the noise.

Smooth Image Button

The smooth image button applies a gaussian smoothing filter to the images in the active window, thereby smoothing the noise within an image. The degree of smoothing can be selected as an option in the config popup. These defaults are user configurable.

F. IMAGE POPUP

Image popups are used to display images from the same series within a display window. Multiple series can be loaded displaying the images in overlapping windows on the screen workspace. Each window can be configured to display only 1 image, as in a cine display, or it can be created as a multi-image window with a selectable number of columns and rows. Images within the window can be viewed in cine mode, paged using the next page button, or scanned by dragging the mouse in the view, text and print mouse modes. The size, shape and position of the image popup can also be adjusted. Each corner of the image window contains a resize corner which can be dragged to enlarge or reduce the image size. Like all popup windows, the image can be closed by clicking the pushpin in the upper left hand corner of the window.

Image popups can also be copied, allowing flexibility for side by side display. This can be used to create two windows which contain the same set of images, but have different image or window characteristics. For example, CT images can be displayed in two windows side by side, one window displaying tissue equivalent images, and the other displaying bone equivalent images.

Images can easily be zoomed to display one image in a window the size of the screen (or greater). Or they can be reduced to display all of the images from a series within a single window.

Active Image Window

There is one active image window for each RI'view application running. This window accepts operator input in the form of mouse and keyboard control. The mouse functions depend upon the current mouse control mode selected in the tools popup. The RI'view status bar on the RI'view
footer specifies the mouse functions which are active within the image popups.

The footer of the image window shows which image popup is currently active by specifying "Active....". To change the active window, simply click on the header, frame, or images of another image window. If the window is hidden, then the window on top can be closed by pulling the pushpin. Or the next window button can be used from the RI'view main console or within the image menu to display each image window in succession. The "back menu option" over the window header can also be used to send an image window to the back of the stack of overlapping windows.

The idea, however, is not to create a confusing screen which might inhibit efficient diagnostic interpretation. Therefore, in the next few chapters, we will discuss each of the image display options with insight as to how to simplify image preparation and review. For the computer literate power user, multiple image windows, duplicate windows, quick keys, and magnifying glasses make RI'view extremely powerful. For the physician who would rather use his/her medical training for proficient diagnostic interpretation, RI'view offers simple screens, templates tailored to standard clinical exams, and intuitive mouse control. These functions couple seamlessly within the user-friendly interface to provide consistent and efficient visualization of diagnostic exams.

**Image Menu**

Over each displayed image there is an image menu. This menu allows the user to quickly access frequently used functions and is available without dragging the mouse cursor to the top of the screen. Simply position the cursor over any of the image windows and click the right mouse button. A menu will appear allowing the operator to select the next window of the same series, page to the next set of images, or select the desired mouse control mode. To select an option from the menu, click on the option with the right mouse button.

The patient and image information buttons, will display information pertinent to the exam and the selected image. To select an image for information, simply place the mouse cursor over that image and press the right mouse button. Then click the "?” from the image menu. The popup at right shows a typical example of the information displayed.

Additional buttons allow the user to change monitors, change window/level algorithms, magnify and cross-reference the active window.

This menu also has a pushpin which can be used to hold the menu open. Once the pushpin is clicked, the menu will remain on the screen. It can then be dragged to a convenient location for quick access. To close the menu, click again on the pushpin to remove it.

**Mouse Control**

The operational mouse functions depend upon the mouse control mode which has been selected in the tools popup (page VI-7). The RI'view status bar on the RI'view footer specifies the current mouse functions which are active within the image popups. The status bar uses the following abbreviations for the mouse and keyboard keys (L=Left, M=Middle,
R=Right, Dbl=double click left, Shift=shift key, Ctrl=control key, <>=Meta(§) key.
The mouse can be clicked to perform an operation, or it can be dragged by pressing one of the buttons and moving the mouse with this button depressed. This is used to resize image windows, to scan through the images during the view, text, or print modes, or to drag out an arrow for annotation.

**Window Size and Location**

The mouse can also be used to resize a window or move it to a new location. To resize the window, grab a corner of the window (resize corner) and drag it to the desired location. RI'view will adjust the images in the window to fit the new dimensions of the window. The window can also be repositioned by dragging the window by the header or the frame (not the resize corners) of the image window. Any window can be moved in this fashion.

**Preserving Image Information**

Since many image processing operations are available to enhance and adjust the image, it is important to know when the image display is suboptimal. In such a case, the image window will be labeled with "Clipped image" or “75% resolution” on the bottom right footer of the image popup.

This notifies the physician that the image has been modified in a way that might reduce the amount of diagnostic information. The following are functions which reduce image information. Having knowledge of these functions will lead to more accurate and reliable use of the system for diagnostic interpretation.

- **Image clipping:** Although clipping allows efficient use of the display screen, it does remove some of the diagnostic information. Therefore, the right footer of the image window will be labeled "Clipped Image" when clipping is in effect.

- **Image reduction:** Adjusting the window size so that the image is displayed with less than the inherent image resolution may also reduce diagnostic perception. Therefore, when this occurs, the “##% resolution” warning indicator will be present. This may be desirable for displaying multiple images on the screen, however during diagnosis, each image should be displayed at or above its inherent spatial resolution.

- **Part of the image is hidden:** If the height of the image window is insufficient to display the entire image, it may hide diagnostic information. When this occurs, the window will be labeled with "Clipped image".

G. **Text Options Popup**

When the text mouse control mode is selected, the text options popup will be displayed automatically. This popup contains selectable options which allow you to select an object or alter its characteristics. The size, thickness, color and object type are fully selectable.
The text mouse control mode is very useful for documenting observations during review, or annotating the images with questions and arrows and having a colleague at another RI workstation bring up the case and give a second opinion. This annotation is saved with the exam and will be displayed even after retrieving the exam from tape several years from now. The current color and text size will be saved as defaults when the save configuration button is clicked in the config popup.

**Color Selection**

The color option determines the color of the next objects to be created in either the image window or the print page window. The color can be easily selected by clicking with the left mouse button over the desired color.

**Siz: text point size**

The Pt prompt has a menu of available text point sizes. The next option can be displayed by clicking over the menu triangle using the left mouse button. Alternatively, the menu can be displayed by pressing the right mouse button over the triangle and selecting the desired size from the displayed menu.

**Thk: Line thickness**

The line thickness can be set from 1 of 8 values by selecting the desired thickness from the line thickness menu. The left mouse button can be used to increment this list, or you can use the right mouse button (menu button) to display the menu and then make your selection. This thickness does not affect the text, however it will affect all of the selected objects.

**Limit:**

This value limits the text size at a particular magnification. Therefore, you can zoom the window to a high degree of magnification to get better measurement accuracy, make the measurement, and unzoom the image and still have text large enough to read.

**Object Selection**

The object selection icons contain the following items in order from left to right:

- **Arrow:** Use the left mouse button to drag out an arrow on the image. The head of the arrow will be created at the origin, and the length and orientation of the arrow will be set where the mouse button is released. The arrow may be moved by dragging the arrow by the arrow's head.

- **Line:** A line of selectable thickness and color may be drawn over an image by dragging the left mouse button similar to the arrow creation. To move the line, select the line by its point of origin (the first end drawn) and drag it to a new position. Or double click over the line's origin to delete it.

- **Circle:** A circle may be drawn by dragging out from the center of the desired region. The center of the circle becomes its origin and may be used to move or delete the circle.

- **Rectangle:** A rectangle of selectable color and thickness may be drawn by dragging from one corner of the desired region to the opposite corner. The first corner of the rectangle becomes its origin and must be used to move or delete the rectangle.

- **Dimensions:** Dimensions may be added to images that have accurate pixel size information. Those images obtained digitally will have this information. Scanned images do not contain accurate pixel dimensions, and therefore may
not be used for dimensional determination unless they are calibrated. To display image dimensions, simply drag from one side of the object to the other. When the mouse button is released, the linear dimensions will be calculated and displayed as text on the image. This text may be moved by dragging it to a convenient location. Color coding may be useful when multiple dimensions are added to a given image.

**Intensity ROI:** A rectangular region of interest (ROI) can be selected by dragging out a rectangle and releasing the mouse button. Upon releasing the mouse button, the average greyscale intensity within the region will be calculated and displayed as text. This text can be moved to a more appropriate position. Color coding of these items makes it easy to determine the corresponding regions if multiple ROI’s are selected.

**Angle:** The user can measure angles by dragging out two lines. RIView will automatically calculate the angle between the two lines, and display it on the image.

**Copy Text Button**

The text which was inserted in each image during interpretation can be inserted easily onto the images in a print page by clicking this button. Any text pertaining to an image in the print page will be copied and sized to match that in the original image window.

The keyboard can be used to enter text annotation into the image. Click first with the left mouse button to locate the lower left position of the text. If the text does not appear immediately when you type, be patient as Open Windows must first create a memory map of each font size you select. Once created, text entry will resume normal speed and the fonts will not need to be recreated until you exit Open Windows.

During the text mouse control mode, the mouse buttons are used to locate the text and drag out arrows. The text and arrows created are linked permanently to each image in the active image window until they are erased using the double click option. When the images are clipped or resized, the text will also be resized and retain the same location within the image. This is not true for text in the print page popup, since the text and arrows are linked to the page itself, and not the individual images. **Warning, if you annotate print page images, and then flip, magnify, clip, move, or otherwise change the orientation of the images, then the arrows and annotation may not point to the desired anatomic locations.**

## H. **PRINT OPTIONS POPUP**

The print options popup is opened automatically when the print mouse control mode is selected. This popup consists of the functions required to create annotated *PaperFilm* print templates.

**Print Template Scroll List**

A print template is a file which contains the available image layout, annotation and exam vocabulary or temporary text. This prompt is a menu of user defined templates which are optimized for specific exams. The layout of the images and text within the print page will be defined by specifications within the selected print template file. The exam vocabulary, created as temporary text, allows the user to drag this text into the image as required. Since this
vocabulary is linked to exam specific print templates, these customized print templates become powerful tools for rapidly annotating specific exams and consistently documenting the presence or absence of pathologic features. They may also be customized for each referring physician or radiologist to provide versatile yet consistent print pages. To select the desired template, click with the left mouse button until the appropriate template appears, or use the right mouse button to display the menu and select the desired option from the menu.

**Create Button**

Once the template is selected, the create button creates and displays a new print page based on the selected templates specifications. When this button is clicked, the print page popup will appear displaying the patient information, additional annotation, and available image positions.

**Delete Button**

If the wrong template was selected, or if the print page is not longer desired, simply click on the delete button and the print page will be deleted following confirmation. If you have created other print pages, they will be displayed after the current print page is deleted. Otherwise the print page window will be blank. If numerous errors were made during the print page annotation or image organization, this button can be used to delete the print page and start over.

**Open Button**

The open button will display the print page popup if it has been closed down by pulling its pushpin. If no print pages have been created, this button will have no effect.

### I. PRINT PAGE POPUP

The print page popup is very similar to the image popup, however the image characteristics, mouse functions, exam annotation, and image display characteristics are slightly different. The print page was optimized for the WYSIWYG (what you see is what you get) display so that producing annotated hardcopy output is efficient and accurate. In contrast, the image windows were optimized for efficient diagnostic interpretation. The image windows have to handle large numbers of images effortlessly, while the print page has to display and annotate a few selected images with great versatility and precision for exam documentation. The following sections will describe the operational attributes of the print page popup.
The number, location, and size of each image within the print page is specified in the selected print template. Default annotation and temporary exam vocabulary may also be specified within the print template file. These templates are customizable and can be tailored for a given exam or referring physician. For example, the color bars at the top and bottom of the image can be color coded for a particular type of exam to make filing easier. The default text and image information can also be changed to customize the template for a particular purpose. And most importantly, the temporary vocabulary can be customized for various exams for optimal image annotation. A more detailed description of the print template file structure can be found in the appendix.

Print Menu

Just like the image window, a menu exists over the print page window. This menu allows the user to quickly access frequently used functions and is available without dragging the mouse all the way to the top of the screen. Simply position the cursor anywhere within the print page window and click the right mouse button. A menu will appear allowing the operator to select the desired mouse control mode. To select an option from the menu, click on the option with the right mouse button.

This menu has a pushpin which can be used to hold the menu open. Once the pushpin is clicked, the menu will remain on the screen. It can then be dragged to a convenient location for quick access. To close the menu, click again on pushpin to remove it.

Print Page Window Size

The size of the print page can be adjusted using the zoom page button located at the top of the print page popup. There are two sizes for the print page. During the addition of images to the print page, it is best to use a small page to show that images are being added to the print page, without obscuring the entire screen. The large print page is used to optimize the image clipping, window, level, position, annotation and other print page characteristics. The print page popup is different from an image window in that the zoom button has to be clicked to alter the size of the window. It can not be adjusted using the window's resize corners. This limits the number of fonts that need to be created to display the page in WYSIWYG (what you see is what you get) format. The dimensions of the large print page are determined from the config popup "Print page height" field. This allows you to optimize the size of the print page to match your workstation's display resolution.

Mouse Control

The operational mouse functions depend upon the mouse control mode selected in the tools popup. The RI'view status bar specifies the current mouse options for the print page popup.
when the print page is active. The status bar uses abbreviations for the mouse keys (L=Left, M=Middle, R=Right, Dbl=double click left, Shift=Shift key, Cntl=Control key, <=(♦)Meta key). The mouse can be clicked to perform an operation, or it can be dragged by pressing one of the buttons while moving the mouse. This is useful to page through the images during the view, text, or print modes, to resize a window, or to drag out a rectangle for clipping.

The operational descriptions of each of the mouse modes is defined starting on page VI-7. Refer to that section for more a more detailed account of each of the mouse control modes and their associated mouse functions.

**Zoom Button**

The zoom button selects between two sizes for the print page. When filling the print page with images, it is best to use the small print page to verify that images are being added to the print page without obscuring the entire screen. The large print page may then be used to optimize the image clipping, window, level, position, annotation and other print page characteristics. The print page popup is different from an image window in that the zoom button has to be clicked to alter the size of the window. It can not be resized from resize corners. This limits the number of fonts that need to be created to display the page in WYSIWYG (what you see is what you get) format. The dimensions of the large print page are determined from the config popup "Print page height" field. This allows you to optimize the size of the print page to match your workstation's display resolution.

**Previous print page**

The previous print page button displays the previous print page if more than one print page has been defined. This button will have no effect if one or less print pages has been created.

**Next print page**

The next print page button displays the next print page if more than one print page has been defined. This button will have no effect if one or less print pages has been created.

**Save button**

The save button brings up the window to save the current exam layout. The window and its functions are described in the next section.

**Copies Prompt**

The copies prompt selects the number of copies that will be created when the images are printed. Each print page is sent once to the printer over the network requiring between 2 to 3 minutes depending upon the image characteristics. Multiple copies are then produced by the printer at 5 copies per minute. Therefore, if multiple copies are desired, it is most efficient to use this function rather than manually printing 1 copy multiple times.
Quality Option

The quality of JPEG compressed print pages can be selected here. This is used for remote printers where the bandwidth of the network is insufficient to support uncompressed print pages.

Resolution Option

The resolution of the print page can be adjusted on a printer by printer basis to match the printing characteristics of a particular printer. Do not increase the resolution of the print page here unless the printer supports it, otherwise the image will only take longer to print with no perceptible improvement in image quality.

Print Button with Menu

The print button can be clicked to print all of the created print pages. This prompt has a menu containing the following options:

♦ All Exams: If this option is selected, then all of the created print pages will be printed.

♦ Current Page: The current option allows you to print only the currently displayed print page. Both of these options create the number of copies specified in the "copies" prompt.

♦ Current Exam: The current option allows you to print only the print pages for the active exam. This is the default option and thus may be activated by just clicking the left mouse button over the print button.

J. Save Layout Popup

The save layout popup is used to save the work that has gone into the exam preparation and review. Image characteristics, window parameters and locations, and print page options will all be saved using the save and continue or save and close button within this popup. It is recommended that you save your work frequently to prevent losing the information you have entered. It is especially useful to save and continue prior to printing out a set of print pages, since this will take some time and someone else may sit down and close the patient without saving your modifications. The save and close button and the discard changes button may be used to close the patient, free memory, and release any database flags that were set for the current patient.

In the save layout popup, there are additional prompts which will allow you to update various database information to allow you keep track of various functions which were performed. These are included for operational control of the exams, since it would be difficult on a networked system to know whether a case had been read, printed or dictated without this information. All of these flags are linked to the username of the person who updates the information. Since each user account is password protected, this will add some security and accountability for clinical operations. The first user to change these flags to "Yes" will be registered as the user who
performed that operation. Thus, once a physician has selected yes for printed, reviewed and dictated, saving additional information (such as archived) by another user will not change the original user links. The current user registered for this program is displayed in the save layout popup to confirm a correct link between the user and the operations performed.

Although the prepared flag is not an available option in the save popup, the prepared flag will be set automatically whenever the exam layout is saved. This flag shows that the patient exam has been prepared and the window layout has been saved. When the technologist is done preparing the case for the physician, they will save and close the patient exam to save their preparation and update the prepared flag. When a physician lists the current patient exams, the prepared field of the patient selection scroll list will show "Y" for the prepared exams.

The printed exam flag is also automatically set whenever the print pages are printed for the exam. Check to make sure that the images have actually been printed, as paper jams and "lost" output will not be reflected in this exam flag.

**Reviewed**

The physician will select Yes after the review has been completed. Then when the case is saved, this flag will be updated with the correct information. **This should only be updated by the physician reviewing the case. It should also never be set back to No, unless a mistake was made, as saving a No will remove the original user's information.**

**Dictated**

Click on Yes next to dictated if the exam has been dictated. This should only be updated by the physician reading the case.

**Lock Exam**

The lock exam button can be used to maintain a patient's exam on the system for a number of days. When the patient is locked, it can be archived, but it will not be auto-removed with the rest of the cases. It also can not be removed with the RI'move program. This function will display a popup which will allow the user to select a period to lock the exam in days.

**Teaching Case**

The teaching case button is used to launch an external application to collect teaching case keywords and other pertinent information. This button is merely a hook into the outside world for facilities which would like to develop their own teaching file applications. This button executes the command entered in the config popup and passes the exam_key on the command line of this application.

**Save and Continue Button**

The save and continue button is used to save the current layout and print pages. This is used to temporarily save your work to prevent a program failure or power outage from wasting the time you have already spent. Click on this button prior to printing in case the printer causes a malfunction.

**Save and Close Button**

The save and close button is used to save the current layout and close the patient. This function will release memory used by the images and change the in-use flag to No within the database. Therefore, this releases the patient for use by other programs, and notifies the archive program RI'store that it is acceptable to archive this patient.
Save, Print and Quit Button

The save, print and quit button is used to save the current layout, print the created print pages, and quit RI'view to relinquish the patient and workstation resources. This is the normal mode of operation when done reviewing a case.

Discard Changes Button

The discard changes button also closes the patient and releases memory, however RI'view will not update the previously saved layout or operational patient flags. This may be used when you have reviewed a prepared case but have not made any changes in the layout, print pages, or annotation.

K. CONFIG POPUP

The config popup contains prompts that gather default information for use during normal program operation. These defaults may be customized by each user, and are saved when the save configuration button is clicked. Then, when RI'view is run again, the defaults will return to their saved values. The configuration parameters are saved in the user's defaults directory in the .riview7 file.

Image Zoom

The default zoom option specifies the zoom factor to be applied to the zoom window in view mouse control mode when the control-Left combination is clicked over an image. The image will be displayed in the zoom window using this zoom factor. The zoom image can be further enlarged by resizing the zoom window.

Magnification

The type of zoom is selectable by the user. The two options are replicative (each pixel is duplicated during image zoom), and bi-cubic interpolation (the image intensities in a zoomed image are obtained as averages of the surrounding pixels). The replicative zoom is much faster, however it produces zoomed images with anatomic borders that appear jagged. The interpolative zoom is slower, however it produces even intensity transitions for images displayed at many times their inherent resolution. It may be useful for the technologists to use the replicative zoom and keep this as their default, since speed is more important than diagnostic quality during image preparation. The physicians will load the prepared study, however whenever an image is enlarged or reduced, bi-cubic interpolation will be used if that is the selected zoom type.

Decimation

The image display when a image is reduced can cause aliasing artifacts with certain modalities and detectors. These artifacts appear as herringbone patterns across the image. They can be removed if a bandpass filter is applied to the image prior to reducing the size. This takes time however and therefore the default is to use normal nearest-neighbor pixel sampling.
Chapter 6. Components of Image Display

Edge Sharpen

The high pass filter adjusts the amount of edge enhancement that is applied when the sharpen button is pressed. This may have to be adjusted for each type of exam that is being displayed.

Edge Smooth

The median filter option is used to adjust the amount of smoothing that is applied when the smooth button is pressed. This also may have to be adjusted for each type of exam that is being displayed.

Print Zoom

The print zoom prompt contains a numeric factor used to enlarge an image in the print page during the print mouse control mode. This is a quick method to zoom an image in the print page. It keeps the image centered, so if the anatomy you want to enlarge is offset, use the clip option to enlarge the image instead of this function.

Show Pt Info

This option determines whether the patient information window will be opened automatically when an exam is loaded. If this option is set to No, then the patient information window can be accessed through the menu available over each image window by using the right mouse button.

Memory Use

The right mouse button can be used to select the desired memory option. The default setting is “Optimize Speed”. However for very large exams, or when using a workstation with limited memory, the other options may be selected to conserve memory and still allow diagnostic interpretation of the exam. The “Conserve Memory” option does not retain any 8bit screen images, and therefore will operate slower since each image must be regenerated during display. The grouped windows and cine functions will not be operational during the conserve memory mode. During the “compromise” mode, screen images are maintained for only the active image window increasing the speed of the display and enabling the cine functions.

Display Warning

If this option is set to yes, then the user will be warned when saving an exam if any images were not displayed during the review session.

Dither Colors

This option is defaulted to Yes, and will dither color images on an 8-bit display to improve the perceived image quality. Dithering has long been known to improve the perceptible color range on limited displays.

Auto Patient List

This option specifies whether the patient list will be displayed automatically where RI’view is started.
PatList Select

There are two available options from which to choose: Load Selected Exam and List Patient Exams. Having Load Selected Exam selected will have the exam load automatically irregardless of how many exams are present for the patient. List Patient Exams will list all the exams for a patient prior to loading the exam. If a patient has only one exam then it will be loaded.

Image Menu

This option allows you to select the size of the image menu which you prefer. Then save the config the new value will be effective when you run RI’view again.

Image Display

This option allows you to select the image you want displayed first. The first image in each series or the middle image.

Layout Postion

This option allows you to choose where you want the Layout List to be positioned when the layout button is clicked.

Default Speed

The default speed specified in the config popup is used to set the speed slider when one of the cine mode buttons in the tools popup is selected. This offers an easy way for physicians to use their own preferential speed for most cine displays, while applying fine adjustments to the speed slider.

Print page height

The print page height is used to control the size of the enlarged print page popup. This value can be customized to the monitor’s display resolution or the user's preference.

Copy Grease Pencil

If this value is set to Yes, then any annotations made over the image windows will be copied automatically to the print pages as these images are added to the print page.

Labels

The image labels prompt allows the operator to select the information that is displayed over each image during normal image display. The values in this prompt allow the selection of image number, orientation, window/level values, RAS image orientation information, contrast, and desc. These values and the displayed information are described in more detail on page VI-21.

Teaching Applications

Enter the name of a unix application which will be executed when the Teaching File button is clicked in the save popup. This application will be passed the exam_key so that patient demographics can be obtained within the application.

Edit Load/Print/WinLev Template List

Click on these buttons to manually update or change the order of items in these lists.
Save Configuration

The save configuration button is used to save the defaults in the "riview7" file in the user's defaults directory. Additional files are saved to maintain the load templates, print templates, and window/level menu items (.riview_L, .riview_P, .riview_W). The defaults directory is specified when the user is added to the database. See the RI installation manual for details on adding users or changing the directory information. Once this information is saved, RIview will use these parameters as the default options during future operation.

L. WINDOW/LEVEL POPUP

The window/level popup is used to set accurate values for the brightness and contrast of an image or images. The window is opened when the window/level mouse control mode is selected. The window will open using the current window/level values from the selected images for you to adjust. This popup is very useful when you desire exact window and level values, or when you wish to set two series of images with the same window and level to determine the change in intensity.

The apply button will set the values in the level and window prompts, or you can select default settings from the menu beneath the apply button. This menu can be viewed by clicking the right mouse button over the apply button. Then select the desired intensity range from the predefined list.

The pushpin may be "pushed in" by clicking on it with the left mouse button. This will keep this window open so you can adjust several windows without reopening it for each window.

Window Prompt

Change the window value if you want to adjust the contrast of the image. Simply enter the new value at this prompt or use the up/down arrows to adjust the numeric value.

Level Prompt

Change the level value if you want to adjust the brightness of the image. Simply enter the new value at this prompt or use the up/down arrows to adjust the numeric value.

Window/Level (W/L) Button with menu

Apply the window and level values to the selected images by clicking on the apply button with the left mouse button. Or you can select predefined values from the menu beneath this button using the menu button (right mouse button).

RGB Button with menu

The RGB button will convert color images to greyscale, or optimize the color intensity tables based on a selected set of images. The smaller the group of images, the better the color differentiation. However, since many systems are limited to an 8bit display, color flashing will occur for those image windows which are not active. Thus, the default is to optimize the colormap for ALL images in the exam. The compartmental histogram weighted techniques used for this optimization have been designed for medical images and will optimize the greyscale content proportionally with the color content. If there is any concern as to the quality of the overall optimization techniques, try toggling between the overall optimization (all exams) and the current image.
M. INFORMATION POPUP

The information popup gives information regarding the current RI'view program. This information is very useful when reporting problems and obtaining upgrades from your RI representative.
VII. Basic Image Display

A. SELECTING A PATIENT’S EXAM

The first step in displaying images, is to choose a patient for display. This is really quite simple, since the system maintains a list of patients in the RI image database, and the select patient popup displays this list and allows you to choose the images you desire. Use the following steps to guide you through this procedure:

1. Click on the select patient button.
2. Use the scroll bar on the side of the scroll list till the desired patient is displayed.
3. Click over the desired patient in the scroll list to select the exam.
4. Click on the load exam button to load all of the series into memory and display them.
5. In Step 3, you may also double-click on the exam to initiate the load function.

The previous steps load all of the series within an exam into memory for display and printing. Each RI'view program will only display one patient at a time. However, multiple exams may be loaded and compared within one Riview session. Furthermore, UNIX is a multitasking operating system, which means that multiple copies of RI'view can be run to display multiple patients. System memory and disk space are the only limitations to the number of images and exams you can display on the screen at one time.

B. SELECTING AN IMAGE WINDOW

After selecting the patient, there should be several image windows on the screen displaying images (if there were several series in the exam). The tools popup should also appear. The layout of these windows will vary depending upon which load template was chosen. RI'view will choose the last image window displayed as the active window.

To make another window active, simply click on the header, frame or images within the new image window, and it will become active as shown by "Active..."
appearing in the footer of the image window. You may also use the next window button from the RI'view main window or within the image menu (image menu | next window).

The images within the active window will accept all of the mouse control functions such as clipping, window/level, or selecting images for the print page. For this chapter, we will consider all of the images within each image window to be similar (no multi-echo MR sequences). Therefore, by default, each of the images within the active image window, whether displayed or not, will be considered selected. When clipping is applied, or window/level, all of the images will be adjusted. The next chapter will discuss the select mouse control mode and how individual images can be optimized within each image display window.

C. Displaying the Next Image

There are many ways to display the next image or page of images. This section will describe the most apparent methods. The next chapter will discuss faster methods of display using speed keys and more subtle techniques.

Next Page Button

The next page button, present on the RI'view main window and in the image menu, can be used to display the next page of images. Click on this button to loop through the pages of images within the active window. If multiple rows are present in the active window, then the last row of images will overlap with the next page of images displayed. Similarly, the previous page button will display the previous page of images.

View Mouse Control Mode

When view mode is selected as the mouse control mode, the page of images can be incremented or decremented simply by clicking the left or middle mouse buttons over the image window respectively. Additionally, the mouse can be dragged horizontally or vertically to page through the images. Dragging up or right will increment the page of images, and down or left will decrement the page of images.

Number of Images Displayed

The number of images displayed in a window is controlled by the column and row buttons in the tools popup. Use these icons to increase or decrease the number of columns/rows within the window. RI'view will also adjust the number of rows depending upon the size and shape of the window.

D. Image Manipulation

This section describes the basic operations that control the image display. Remember that in this chapter, all of the images within a window will be treated similarly.
Window / Level Control

Select the window/level mouse control mode from the tools popup. It will take just a second for RI'view to prepare the images and display them with their current window and level values. When the display stabilizes and the window/level cursor appears, the images are ready to be adjusted. Simply depress the left mouse button within the active image window and drag the mouse to obtain the desired result. Horizontal motion adjusts the image contrast (window). Vertical motion adjusts the image brightness (level). The combination of the two requires some getting used to, however it provides rapid adjustment of the image intensities. Notice that all of the images within the image will be adjusted, even those that are not displayed and remain in the background. Prove this to yourself by clicking on the next page button to display the next page of images. Note, the cursor can be dragged outside the window while adjusting the window/level as long as the left mouse button remains depressed. You must start this operation within the image window however.

As you fine tune the image intensities, notice that the fine detail improves as you release the mouse button. RI'view optimizes the intensity transformation tables and redispaly the image to maintain the highest image quality. During the intensity adjustment (dragging the mouse) speed is optimized rather than image quality.

Each time the window and level are adjusted, RI'view needs to prepare the images for the 8 bit display and load the images into high speed memory. The speed of the displayed images will decrease momentarily while the 16 bit images are being loaded into high speed memory and displayed. Once all of the images within the window have been displayed, they will resume the normal speed of display.

RI'view Status Bar

The status bar on the footer of the main RI'view window will display helpful hints regarding the effective mouse controls. Refer to this area when making image adjustments until you are familiar with all of the mouse control modes.

Multi-Image Display

If an image window displays more than one image, it is considered a multi-image display. The only difference between this and a single image display is that when the next page button is clicked, the page of images is incremented. To adjust the number of columns and rows, use the column and row buttons in the tools popup. You may also resize the window to change the number of rows.

Adjusting the Size of the Image Window

When the image window is split into multiple rows and columns, the images may become smaller to fit within the window. It therefore may become necessary to increase or decrease the size of the image window accordingly. This is accomplished by positioning the cursor over the resize corner of the image window and dragging it to a new location. RI'view will
adjust the size of the images, determine the number of rows, and redisplay the images. Remember that an additional row of images will not be added unless 75% of each image can be displayed in that last row.

Enlarging the image in this fashion slows down the display momentarily, due to the number of computations required to recreate the zoomed image. Once all of the images have been displayed (created in the enlarged form) the display will resume its rapid display. The speed of this operation may be increased by selecting "replicative zoom" from the default zoom menu in the config popup.

Alternatively, the zoom button and associated menu on the tools popup may be used to adjust the image size. This option allows discrete adjustment of the image dimensions (1.5x, 2x, 3x, ...).

**Clipping the Images**

Select the clip mouse control mode from the tools popup or from the image menu. Start at the upper left corner of the region to clip, and drag down and to the right to create the rectangular clipping region. Release the mouse button to accept the size and shape of the rectangle. Once the rectangle has been created, you may reposition it by dragging it with the left mouse button. Then click the middle mouse button to accept the rectangles size and position, and perform the clip. If you make a mistake, double click over the image window to reset or remove any clipping. To clear the yellow clipping rectangle and start again, simply double-click the left mouse button.

Each image window only allows the selection of one clipping rectangle. This limitation is not present in the print page window. This is not really a limitation since you can create duplicate image windows and clip them differently. These functions will be discussed further in the next chapter.

**Annotating Images**

Select the text mouse control mode from the tools popup. The text popup will appear on the screen with options for controlling the size and color of the text, arrows or other selected objects. Try creating an arrow by selecting the arrow type and dragging the cursor across one of the images. If the arrow is in the wrong location, or pointing the wrong way, simply double click over the head of the arrow to erase it and start again. To move the arrow, drag the arrow by its head to a new location.
To enter text over the image, select the size and color of the text from the text popup and click where you wish to start the text. Then type the text on the keyboard. Press <ENTER> if you wish to start a new line. The line spacing will be determined by the size of the font you have selected. To move the text, simply orient the cursor over the text and drag the text to a new location.

As the image is enlarged or reduced, the text and arrows will change size accordingly. Therefore, keep all annotation and arrows within the image borders since they are linked to that particular image. If the window is changed to a single image display, the text that goes off the image will be clipped. Other adjacent images may also be displayed on top of the text that overflows the image borders. The print page does not operate this way since the text and arrows are linked to the page rather than to a particular image.

This process is analogous to the black grease pencil used to mark film. During review, this feature becomes very useful to mark those images that you wish to scrutinize later. Or you can circle images with a different color to mark those images you wish to include in a print page. Or simply annotate the case for another colleague to review. Your imagination will dictate the power of this function.

**E. PRINTING IMAGES**

To begin, select the print mouse control mode from the tools popup or from the image menu. The print options popup will appear automatically when this mode is selected.

To create and print a page of images, use the following steps:

1) Select a print template from the print options popup
2) Create the print page
3) Select the images which will appear on the page
4) Annotate the print page using the text mouse control mode
5) Select the number of copies
6) Print the PostScript print page to the PaperFilm Imager

The following sections describe each of these steps in greater detail.

**Creating a Print Page**

Select the desired print template and click on the create button in the print options popup to create and display a new print page. The print page will contain available image locations (blank) and default annotation specified by the print template selected. The print page will appear in a small window first, however this can be enlarged by clicking the zoom button. Like all windows, the print page popup can be dragged to a new location or closed by pulling the pushpin.

**Selecting Images for the Print Page**
In the print mouse control mode, the left and middle mouse buttons allow you to select images from the image windows to fill available positions within the print page. If the left mouse button is clicked over one of the images in the image window, it will appear in the next available position in the print page popup. Each successive image selected with the left mouse button will be added to the next available position in the print page popup until all of the image positions are filled. Use the small print page during the image selection to verify that the images are being inserted into the print page. This will make more screen space available for image display and selection.

The middle mouse button is used to select all of the images for multiple print pages. When the middle mouse button is clicked over an image, all of the images within the series will fill any available positions within the current print page. If there are too many images for the print page, new pages will automatically be created for the remaining images using the currently selected print template. This is the recommended way to print all of the images within a series.

**Deleting an Image in the Print Page**

To remove an image from the print page, make sure that you are in the print mouse control mode and double click over that image in the print page. This will remove the image and make that image location available for another image.

**Optimizing Window/Level of Print Images**

The window and level of the images within the print page can be adjusted using the window/level mouse control mode. First select the window/level mouse control mode, wait till the window/level values appear over the images. If the window and level values appear in an active image window rather than in the print page, simply click anywhere within the print page to make it active. Then drag the mouse over the print window to adjust the values. Horizontal movement affects the contrast (window) of the images. Vertical movement affects the brightness (level) of the images. Since all of the images are assumed to be selected by default, they all will be adjusted together.

If a new image is added and needs to be adjusted separately, see the print page optimization section of the next chapter.
Chapter 7. Basic Image Display

Showing Multiple Print Pages

If the print page has been closed, or if multiple print pages have been created, click on the show button to display the print page, and then click on next print page button or the previous print page button located on the top of the print page. These display functions are useful to verify the image characteristics, annotation, and layout of the print pages prior to printing.

Zooming the Print Page

Two sizes of the print page are available. The small size is useful to verify that the selected images are being inserted into the print page popup. The large size is useful to clip the images or add new annotation and arrows to the print page. The zoom button located on the top of the print page toggles between these two sizes.

Zooming Images within the Print Page

The images within the print page can also be enlarged. Select the print mode and use the shift-Left mouse combination to click over an image and enlarge it. The image size can easily be adjusted by dragging the left mouse button vertically while the shift key is depressed. Alternatively, the middle mouse button can be clicked to magnify the image by the default print zoom factor selected in the config popup. This function simply enlarges the image around its center, so if the anatomy you want to enlarge is not in the center of the image, see the section on clipping images in the print page discussed in chapter 8 (Print Page Optimization).

Printing All the Print Pages

Once the print pages have been created, they may be printed by clicking the print button. This button is actually a menu button, however clicking with the left mouse button will select the default menu option which is to "print all".

It is recommended to save your work prior to printing the images, since printer failures, or running out of disk space may lock the system and prevent you from saving the exam layout (RI'view window | save | save and continue). You can also select save and print, and save, print and quit as alternative functions. These latter options do not allow you to print selected images however.

The print command will print to the default printer selected in the config popup. It will first create the PostScript file required by the Paper Film Imager, and then add it to the RI workstation's print queue. This queue will feed these images, in order, to the printer as it becomes available. Once the PostScript image has been created and added to the printer queue, the remaining portion of the print will be accomplished in the background.

At this point, you can close the patient and begin reviewing another case. Or you can run another copy of RI'view to begin loading the new exam for review. Be careful not to have too many programs running or you may run out of system memory (RAM). This will have unpredictable results on the various programs loaded, depending upon which program requires additional memory first.
F. SAVING CURRENT DISPLAY ATTRIBUTES

To save the current layout and display attributes, click on the save button on the RI'view main window to display the save layout popup. Select Yes next to any of the options which have been performed. For example, since the exam has now been reviewed, select Yes next to the reviewed option to flag this patient as reviewed, and click on the save and close button. If you wish to continue modifying the layout, or printing the case, click on the save and continue button. If you do not wish to update the reviewed flag, or save the layout modifications, then click on the discard changes button to close the exam. When you save the exam layout, the prepared flag will be updated automatically. Similarly, the print flag will be updated when the print pages are printed.

During the review and print process, the images and windows are optimized, annotated and displayed differently than when they were first loaded using the load template. This layout, all of the annotation and print page specifications can be saved so that in the future, the exam will be displayed in the same way. This was designed to reduce duplicate effort by allowing the technologist to prepare the image display and the physician to simply review and dictate the prepared images. Other obvious advantages are the ability to review the case several years later and retain the print pages, image display characteristics, and annotation documenting the presence or absence of pathologic features.

Currently, films are prepared by the technologist per protocols and guidelines developed over time by the physicians. Then the images, in their optimized state, are reviewed and interpreted by the physicians. RI'view promotes a similar work flow by allowing the technologist to prepare the image display windows, with guidance from the load templates, and then save the optimized layout. The physician will then select the exams that have been prepared for review. The technologist could also have been instructed to prepare basic print pages prior to the physician's review process. Then the physician could review the images, annotate the print pages, and print them.

The various updatable patient flags within the database allow the physician to determine which functions have already been performed on a given exam. This simplifies the operational work flow by conveniently marking those functions which have already been performed.
VIII. Advanced Image Display

A. SELECTING THE LOAD FORMAT

To select the load format, click on the format button on the main console of Riview. Select the desired template from the scroll window by clicking with the left mouse button over the template name. These options are specified in the ".riview_L" defaults file in the user's defaults directory. New load templates can be created, or old ones modified to match a particular acquisition protocol (usually these are exam and modality specific).

The load format is a template file which determines the default layout of each series. Each series is keyed to the template by series number or exam description, assuming that acquisition protocols are established for each type of exam. If additional series are added to the acquisition, default values may be specified in the template file to approximate the layout of these additional series.

These templates greatly reduce image preparation time and maintain consistency in the image display. The format of these files will be described in detail in the appendix so that you may customize them for your facility.

B. IMAGE OPTIMIZATION

Advanced image optimization, means being able to apply virtually any image processing or display function to any individual image within the image window or print page. This is especially useful for MR images which vary in intensity from image to image depending on the acquisition pulse sequence, echo time, or proximity to the detector coil. This section will discuss some of these techniques and their recommended applications.

Selecting Individual Images

In order to apply image processing functions on individual images, those images need to be selected. If none have been individually selected, then all of the images will be affected by the clip or window/level operations.

To select individual images, click on the select mouse control mode in the tools popup or the image menu. This mode will allow the mouse to select any combination of images. Click over an image with the left mouse button to select or unselect it. This is a toggle function. You may click over as many images as you want, however the images in the next page will
need to be selected separately when using the left mouse button. A cyan rectangle surrounding the image will designate the image(s) as selected.

To select even or odd images, click the middle mouse button over an even or odd image respectively. This operation selects all of the even or odd images, even those that are not displayed. To clear all of the selections, either click the select mouse control mode again, or double click the left mouse button to reset (clear) any selections.

A quick alternative to selecting the select mouse control mode, is to use the modifier keys. The control key can be depressed while in the clip or window/level mouse control modes to enter the pseudo select mode. With the control key depressed, the mouse will function very similar to the select mode allowing you to select individual or even/odd image combinations.

**Individual Image Window / Level Control**

When individual images are selected, they will be adjusted separately. To change the image selection, depress the control key and select the desired images. This function will allow you to change between even and odd images very easily. This function eliminates the need to go back and forth between the image select mode and the window/level mode and should enhance performance significantly.

This works very well for multi-echo MR images where you will select the odd images, adjust them, and then switch to the even images to adjust them. If you want to go back to the odd images, simply depress the control key and click with the middle mouse button over an odd image. To clear individual image selections, either double click the left mouse button with the control key depressed, or click on the select mouse control mode icon.

You may also use the window/level popup for accurate adjustments to the window or level. Click on the middle mouse button with the shift key depressed from within the window/level mouse control mode. The window/level popup will appear for you to accurately define these values. This is very useful when you wish to set two windows with the same intensities (for example: post-gadolinium MR). To accomplish this, adjust the values in the window/level popup. Click on the apply button to set the current values. Then select the new window to make it active and again click on the apply button to set the values for the images in that window. Remember, it will only affect the selected images within the active window (or all if none are individually selected). You can also use the menu over the apply button to select predefined intensity ranges by using the menu button (right mouse button).

**Sharpen Edges**

Click on the sharpen button in the tools popup. Depending upon the frequency content of the images and the background structure noise, this may enhance the perceptibility of fine structures. If the noise or background structure is predominant, then edge enhancement plays a minimal role in diagnostic enhancement.
Smooth Image Noise

Similarly, the image can be smoothed if the noise is too great. While this may reduce the apparent noise in an image, it also visibly blurs the fine structure and may limit diagnostic perception rather than enhance it. Use discretion when applying either the sharpen or smoothing filter during diagnostic interpretation.

C. Advanced Display and Review Modes

Ri’view is very versatile when it comes to displaying images. Single or multi-image displays may be viewed using the cine function. Multi-image paging is also useful for displaying multi-echo sequences side by side. Multiple duplicate image windows add unlimited resource for allowing different features of the image to be enhanced in each window (CT - bone and tissue equivalent windows for example). Ri’view has been designed to meet the complex challenges of diagnostic imaging while providing a consistent and user-friendly interface.

Cine Display

Many times, different features of the image are apparent during cine or motion display that are not visible during static display. Since the noise in a given image is usually random, when multiple images in a sequence are displayed in motion, the human eye is able to follow the real anatomic structure and filter out the random noise, thus improving the diagnostic perception of small or low-contrast objects.

To operate the single-image cine display, adjust the window so that only one image is displayed (join button or create duplicate window). Once one image is visible, all you need to do to initiate the cine mode is click on the cine button and then select one of the buttons in the cine popup (forward, reverse or end-reverse). To alter the default speed, drag the speed slider or change the default in the config popup.

Cine mode may also be activated during multi-image mode, except that the cine function will page through the images. This is very useful to display a multi-slice cardiac or multi-echo MR study. Have the number of rows and columns set up to display all the slice locations, and then when the cine mode is activated, each slice location will be incremented with the same location at a different point in the cardiac cycle. Thus several beating sections can be displayed side by side. Although this is very versatile, it may be rather slow if many slices are selected. Limit the number of slice locations to display at one time by loading them in a limited fashion. Then the display speed will be acceptable.

If another window is selected, then the cine mode will be halted until that window is again active. Each window can be set up of have a different display speed, and you can click between them to start them in motion.
View Mode Options

Select the view mouse control mode to allow flexible control of the pages of images and multiple windows. When this mode is active, the mouse can be dragged over the image window to increment or decrement the page of images. This function allows the images to be scanned very rapidly. If the images have been modified using window/level, or enlarged, it will take a moment to prepare the images in high speed memory so that they can be displayed quickly. During this period, the images will be displayed one by one and the RI’view status bar will show "Preparing high speed memory...".

Other options are also available during the view mode. By holding down the meta key (✧), you will enable the magnifying glass mode. This magnified region can be moved over various portions of the image window to enlarge various anatomic attributes. The default size of this magnifying glass is established when RI’view is first run. If a larger or smaller region is desired, click on the left or middle mouse button to increase or decrease the size respectively.

Images can also be selected for the print page within the view mode. Hold down the control key to enter the pseudo print mode. Then use the left or middle mouse buttons to copy single or multiple images to the current print page respectively. This improves the speed with which images can be reviewed and prepared for printing by reducing the number of mouse strokes required for each function.

If the shift key is depressed while in the view mouse control mode, the pseudo text mode is enabled. While in this mode, you can drag out arrows or move various objects to new locations within the image. You can also double click to remove selected objects as long as the shift key remains depressed. Releasing the shift key resets the view mouse control mode functions.

Annotate Display Mode

The text mouse control mode, while allowing the physician to add objects such as arrows and text to the image, also allows additional flexibility for scanning through the pages of images. The left mouse button is used to position text and drag out various objects. When shift is depressed, the images can be incremented using a single click, or paged by dragging the mouse. This offers the ability to page through the image quickly and then add arrows to those images which you want to identify or put in the print page later. A yellow rectangle may indicate that the image has some visible pathology, a cyan circle may signify that the image should be put in a print page and annotated. You alone may decide the power and flexibility of this mode.

Print Display Mode

Several additional functions are available in the print mouse control mode that were not discussed in the basic image display chapter. When selecting images for the print page, it is very useful to be able to page through the images quickly to select individual images. While you can use the next page button on the RI’view window or within the image menu, this method is still rather cumbersome. Therefore the ability to page through the images while depressing the shift key...
has been added for improved functionality. This allows the physician to quickly review the case and select the images for the print page.

**Multi-echo MR Sequences**

In order to display a multi-echo MR sequence properly, you can use a multi-image window and have the images displayed side by side. You can also sort the image scroll list by echo time (TE) and load the images this way. This will produce the early echoes appearing at the beginning of the window, and the late echoes grouped together at the end of the window. By creating duplicate windows from selected even or odd images, you can create duplicate windows each containing a specific echo time. Since the images can be windowed and leveled separately even within the same window, it is not mandatory to separate the echo times into different image windows.

If you want to be able to scan through the images with one echo always at the side of the other, then create a 2 column by 1 row display for the multi-echo sequence. Use the split button to create 2 columns, and then adjust the height of the window to display only 1 row of images. When the view mode is operational, dragging the mouse will page through the multi-echo sequence, keeping both images side by side.

Evaluate the versatility of the display, try different options, and then decide based upon how your physicians currently read images, which type of display will best accommodate their work flow.

**Display Image Labels**

The image labels, such as image number, location, window/level and RAS information may be displayed within each image to quickly identify particular images and illustrate their orientation. Select the label image button on the tools popup to activate the label mode. The desired labels can be selected in the config popup. This option will update all image windows. If you click on the label image button again, it will turn off the labels.

**D. WINDOW CONTROL**

While displaying each series in a separate image window gives the system great versatility, it does not allow the same series to be displayed in two windows. *Is this really necessary you may ask? Actually it is!* How else would you display an image from a CT series with both bone and tissue equivalent
windows appearing side by side. The ability to create duplicate windows with individual image characteristics greatly enhances the efficiency of diagnostic interpretation. By using different windows to display both bone and tissue equivalent images, the physician is not required to perform the tedious task of switching between the two display characteristics. With this in mind, the following functions affect the creation, deletion and display of the image windows in the workspace.

Window control options appear in the menu of the window control button located on the tools popup. Use the left mouse button to select the default option or the right mouse button to select an option from the menu.

**Creating Duplicate Image Windows**

The create duplicate window function is the default option in the window control menu. This option is used to create a new window containing the selected images within the active window. The duplicate window is designated by "Copy of S#" at the top of the window where ">#" represents the series number. If you have not selected any individual images, then all of the images will be copied to the duplicate window. If you have selected the even (second echo) images, then only those will be copied to the duplicate window. If only 1 image is selected, then the create duplicate window function will create a window with only 1 image in it, which you can then enlarge to elucidate the anatomic detail.

This option allows you to create a window with a subset of images to display. Or you may wish to copy all of the images but display them differently in the new window. For example, it is very useful to display CT images with both bone and tissue equivalent windows. Since you cannot display the same image within one window with both characteristics, try creating a duplicate window and then adjusting the window/level of the duplicate window.

This feature has also been used to create a large multi-image window with all of the images appearing very small to get an overview of the series or to quickly choose images for the print page. Then create a duplicate window which you will use for review (display larger images).

However you use this feature, the load templates can be modified to perform this step for you. Duplicate windows with different characteristics can be generated automatically by listing duplicate series descriptors for the same series number. The appendix will describe the load format file structure and give specific examples.
There is no restriction on the number of windows you can create, bearing in mind that you will, at some point, run out of memory or slow the system down due to the overhead involved of handling multiple windows containing multiple images.

**Deleting Duplicate Image Windows**

If you have created a duplicate window that you no longer need, simply make the duplicate window active (*Active...*), and select delete duplicate window from the window control menu in the tools popup. This function will not delete an original window, since that window controls the original 16 bit image data loaded into memory.

**Individual Window Display**

The individual window display function will close down all image windows except the currently active image window. Then when the next window button is pressed, the windows will be cycled as normal, however only one window will appear at a time. This will simplify the complexity of the multi-window imaging system. To cancel this option, select the display hidden windows option from the window control menu.

**Hiding Image Windows**

You can hide the active window by selecting this option. This will limit the number of windows displayed when the next window button is clicked. This feature can be canceled by selecting the display hidden windows option from the window control menu.

If you only want to hide one of the image windows temporarily, you can also pull the pushpin in the upper left corner of this window. The *next window button* will redisplay the window as you loop through the windows.

**Displaying Hidden Windows**

This option will open all of the image windows that have been closed either by pulling their pushpin, or by hiding them with the options in this menu. This function will cancel the individual window display and unhide any hidden windows.

### E. PRINT PAGE OPTIMIZATION

The basic operations for selecting images for the print page and annotating them were discussed in the previous chapter. This section will discuss more advanced features for optimizing and editing individual image characteristics for final printout.

**Filling Multiple Print Pages**

You can create multiple print pages from the images within an active image window if you desire. Just click the middle mouse button over any image in the series while in the print control mode. This function will copy all of the selected images to as many print pages as are necessary. As each print page becomes full, a new print page will be created using the current template attributes specified in the print template popup. The first image will start in the next available print page location, so if the page is already partially full, the images will continue to fill the current page and any additional pages that are required.

This function is very useful when you wish to print all of the images within a selected series to the referring physician or to fully document the diagnostic exam.
Moving Images Around

When you select images from the image windows to be put in the print page, they are automatically assigned to the next available location. The order of these locations is determined by position in the ASCII print template file as discussed in the appendix. To change the order of the selected images, several options are available when the print mouse control mode is active:

♦ **Exchanging Images:** You can exchange the positions of images by dragging the cursor with the left button depressed from one image to another. The first image will then be exchanged with the second image.

♦ **Copying Images:** You can copy an image to another location by dragging that image with the middle mouse button depressed to the new location. The image you have selected will then appear in both locations. This is very useful to duplicate the image and then invert the intensity, or clip the image to have it appear as a large cutout for the adjacent image.

Selecting Individual Images

You can select individual images within the print page when in the select mouse control mode. Simply click over an image with the left mouse button to select it. A cyan rectangle around the image will appear when the image is selected. When multiple images are selected, the clipping and window/level functions will apply to all of the selected images, not just one. This is a toggle function, so you can turn images on or off in this manner.

If you want to clear all of the selections, simply double click with the left mouse button. The active mouse functions are displayed in the RI’view status bar.

Window/Level Selected Images

Once individual image have been selected, the window/level control will affect only those images. Be sure that you have selected the window/level mouse control mode, and that the window and level values appear over the selected images. If the window and level values appear over an active image window, then click on the header, frame or within the print page window to make it active. Remember, dragging horizontally will affect the contrast, and dragging vertically with adjust the brightness within the selected images.

Clipping Selected Images

Clipping is also available within the print page popup. This option differs slightly from the clipping available over the images window. First of all, the aspect ratio of the clipping rectangle is fixed by the dimensions of each print page image location. This is to show you exactly how the image will be clipped for that print page location. Since print templates can have images of different size and shape, drag out the clipping rectangle.
over the image you want to clip, or the wrong aspect ratio may be applied. RI'view will not change aspect ratios if you move the yellow rectangle over an image with a different aspect ratio.

It is also best, if you are selecting multiple images to clip, that those images exist in locations of equal size. The clipping will still be performed if this is not true, however it will make its best guess at the applied clipping. Generally this means that either the height or width of the clipping rectangle will be enlarged to display the image in a different sized location. The dimensions of the clipped image will never be decreased, since this may obscure diagnostic information.

This clipping also differs from the image window clipping in that if no images are selected, then only the image that is under the clipping rectangle will be clipped. In the image window, all of the images are clipped together. This is done to preserve the image display characteristics and optimize the use of the display screen. If one image were left unclipped in a multi-image display window, then there would be a lot of blank screen space surrounding each of the clipped images. On the print window however, the images can each have different sizes, different clipping dimensions, and different window and level values. Since the printed output is used to document the case and ultimately portrays the quality of the diagnostic facility, it is mandatory to present the highest quality images.

Advanced Image Annotation

In addition to creating text and arrows, you can also move these items around or delete them as you desire. Exam specific vocabulary is also available within the print page. This text is displayed in red and minimizes the amount of keyboard interaction required to document a diagnostic procedure. This text is considered temporary text since it will not be printed with the page until it is dragged onto the print page. When the text is dragged into position, the size and color will be set to the characteristics selected in the print options popup. These advanced functions are available when the text mode is active.

♦ Selecting Text and Arrows: Click over the text or over the head of an arrow to select it. Try not to move the mouse as you click otherwise RI'view will think that you just want to move that one item. Each time you click over an additional item, it will be selected. These selected items can be moved or deleted as a group.

♦ Moving Text and Arrows: To move an item, click over the item and drag it to a new location. For arrows, remember to click near the head of the arrow. For rectangle, circles, dimensions and ROI objects, select these items near their origin (the point which was first created). For the circle, this is the center. If only one item is moved, then it will be unselected when it is relocated. Group selections will remain selected after the move. Also, it is not important to click over one of the items to move a group of selected items. Simply drag the mouse with the left mouse button depressed till the text appears where you desire. To clear selected objects, simply click on the middle mouse button.
♦ **Copy and Paste Text:** After text has been created, deleted or moved, it is copied to the clipboard. You can then paste additional copies of this text into the image at the current cursor location by pressing the *Paste key* on the keyboard. You can also copy text into the clipboard by pressing the *Copy key* while the cursor is over the desired text. Again, use the *Paste key* to deposit additional copies over the desired image locations.

This function will allow you to copy exam vocabulary from one print template to another when they have been created in the print page popup.

♦ **Deleting Text and Arrows:** You can delete an item or group of items by double clicking with the left mouse button over the desired objects. If you delete a single line of text by accident, it remains in the clipboard and can be restored by pressing the *Paste key* on the keyboard.

♦ **Exam Vocabulary:** This optional vocabulary consists of exam specific anatomic locations or descriptive diagnostic phrases which are frequently used to document a particular procedure. Each print template can be tailored to a particular exam and include its own vocabulary. This text, since it is considered temporary, will appear in red until it is made active by dragging it into location. You will be able to tell the difference between the red color of the exam vocabulary and the red given to permanent text. **The exam vocabulary will not appear on the printed page until you drag it to a position on the page at which time it will appear with the color and size that are selected in the text options popup.** Exam vocabulary, copied in this manner, reduces the amount of keyboard interaction required to annotate the print page. Additional text may be added at any time by simply typing at the keyboard. The print templates will be discussed further in the appendix.

If you are using a greyscale monitor, you may designate certain locations for the exam vocabulary to differentiate it from the permanent text. For example, you might always have it located on the left side of the page, near the top, or in very small print.

**Deleting a Print Page**

If you no longer want one of the print pages, it can easily be deleted from the group by clicking the delete button in the print options popup. This function will remove the currently displayed print page and display the subsequent print page. If no other print pages exist, the print page popup will be blank.
Use discretion when deleting a print page. If the pages have been printed and sent to the referring physician as documenting evidence in the case, DO NOT delete the print pages and save the exam simply to save space. First of all, these print pages take VERY LITTLE SPACE on the disk to store. They are merely a list of image locations and attributes. Furthermore, it will be very useful to restore this patient years from now and know exactly what was printed and sent out to the referring physician. Finally, when duplicate prints are requested, you do not need to recreate the print pages layouts, they will appear exactly as they were saved using "Save and close" or "Save and continue" buttons in the save layout popup. Therefore, each time to click the delete print page button, you will be required to confirm the delete request.

**Printing One of the Print Pages**

Sometimes it is desirable to print only one print pages. Maybe the printer was jammed, or an additional copy of one of the print pages was requested. Instead of just clicking with the left mouse button to print "all" of the pages, use the right mouse button to display the menu under this button. Then select "Current" from the menu to print only the currently displayed print page. If you want to print a different page, use the show button until that print page appears.
RI'store was designed to save a patient's images to a backup tape, allowing retrieval of these images at a later date. Helical scan tape technology was chosen due to its high capacity (2-12 GBytes), low cost ($10.00/tape), availability, and high reliability (unrecoverable error rates as low as 1 in $10^{15}$). At the 2 GByte capacity, approximately 200 MRI patient studies can be stored on a single tape costing 5 cents/patient. Any tape media that uses standard UNIX device drivers should be acceptable (DAT 4mm, Exabyte 8mm, 9-track 1/2inch). The baseline specifications for these devices should be based on reliability (less than 1 error in $10^{13}$ bits), provide quick archival (approx 10MB/min sustained transfer rate), and provide quick access to the patients at the end of a tape (less than 5 minutes to restore any exam).

RI'store archives and retrieves an entire patient's exam. This ensures that all of the corresponding information which has been created during the review and analysis process remains intact with the patient procedure. Information describing image annotation, print page layouts, review organization, and database information are kept with the patient's exam in one tape file. If this information is retrieved, and the study is again reviewed and further annotation is added, it is recommended practice to again archive this patient. This is analogous to a word processor in which it is recommended practice to save the current file frequently with each of the major modifications.

The following sections describe the operational details of the RI'store program and describe each of the programs functions.

**A. SUGGESTED OPERATING INSTRUCTIONS**

It has become our policy, and our strong recommendation, that rather than deleting any exam, it must be removed during archival using the auto-remove function of the RI'store program. This will ensure that any modifications to the exam configuration and layout will be saved to tape before they are removed.

To **archive** a patient's exam using RIstore, perform the following operations (the recommended dual tape backup scenario will be discussed starting on page IX-14):

1. Run RI'store on the workstation with the tape drive attached.
2. Insert that tape into the drive and click on the mount button.
3. Verify the tape number, tape set, and tape drive.
4. Click archive to open the archive popup.
5. Select the desired exams.
6. Set the auto-remove function to ON.
7. Click on the Archive and Quit button to begin operation.

To locate a patient's exam, perform the following operations:
1. Click on the search button to open the search window
2. Enter several characters of the patient's last name
3. Click on search
4. Find the patient in the scroll list.
5. Determine the tape set, position, and tape number

To retrieve a patient's exam, perform the following operations:
3. Insert the correct tape and click on the mount button
4. Verify the tape set and tape number
5. Click on retrieve to open that tape's log
6. Locate the desired patient by name or position
7. Select the desired patient(s)
8. Click on the Retrieve and Quit button

**B. SELECT TAPE SET**

The tape set option is used to create different sets of sequentially numbered tapes. One main archive set may be used for normal archival purposes and additional sets for each physician or research project. During the installation, a default tape set was created for the facility. Tape sets can be designated as one of three types: 1) Normal, 2) Initial, and 3) Active.

The normal tape set is used for single tape archives and for additional tape sets used for research or personal purposes. This type of tape set usually has the auto-remove function defaulted to off. The Initial and Active tape sets are used to create duplicate tape sets for security and reliability. The best way to create dual tape backups is to use two RI workstations, each with its own tape drive in separate rooms or facilities. One workstation will be designated as the initial backup and will archive the unarchived exams with auto-remove turned off. The second workstation will be designated as the active backup and will archive only archived exams and then remove the exams. This will ensure that each patient is archived on both tapes. Thus, if fire or theft should occur, the alternate copy of the exam will still exist on the other tape set. This dual tape protocol will be discussed in greater detail starting on page IX-14.

RI'store will number the tapes sequentially during initialization and maintain a list of the archived exams in the RI archive database. Each tape is digitally labeled during initialization with the tape set name and the number so that it can be identified by the computer even though the exterior label may have been incorrectly labeled or worn off.

To create additional tape sets, refer to the RI installation manual.

**C. INITIALIZE NEW TAPE**

The initialize tape function is done when first operating the RI'store program, and when each sequential tape becomes full. This function allows the proper preparation of a new archive tape
for a particular tape set. During this process, RI'store will first see if the tape is already initialized by checking for the tapes Unique ID label at the beginning of the tape. If this label exists, the tape will not be re-initialized. Therefore, once a tape has been labeled, it can not be changed, short of magnetically erasing all of the digital information from the tape.

If the tape is truly blank, RI'store will increment a sequential tape counter, advise the operator how to number the tape, and proceed with the initialization. RI'store can not identify unknown foreign backup tapes (tapes created by programs other than RI'store), therefore make sure that a truly blank tape is being initialized.

When a new tape is being initialized, always WRITE-PROTECT the previous tape if there is one. Although this program has fail-safe mechanisms to prevent overwriting the archive tape and its patient information, other UNIX programs do not check for existing information prior to writing tape files. Be especially careful if the tape drive is being used for other tape dumps other than the RI'store archive. In a network environment, a knowledgeable operator could mistakenly overwrite the archive tape from another system. Therefore, it is advisable to use a dedicated tape drive in a secure location for archival purposes only. Purchase another tape drive for other backup requirements.

For reliability reasons, you may wait to remove the exams from the scanner until the exams have been archived and the tape has been write-protected.

Multiple tape sets should be created to improve the archive security. The main archive could be named with a facility identifier and used to archive all of the original patient information. A backup copy could then be created to take off-site for protection. If the doctors want to keep their own patients separate, then create a tape set for each of the doctors.

Be sure to label each tape with the following information:

- tape set name
- tape number
- date of creation

Perform the following operations to initialize a new tape:

1. Select the tape set from the tape set menu.
2. Click on the init tape button.
3. Label a new blank tape with:
   - the name of the tape set
   - the tape number specified by RI'store
   - the current date
4. Insert the labeled tape into the tape drive
5. Click on YES to proceed
6. Verify initialization once more by clicking on YES

**D. MOUNT TAPE**

When an archive tape has been inserted into the tape drive, press the mount button to mount the tape. This will read the tape's ID label and update the appropriate tape set and tape number on the RI'store main console. This function is useful if the external label has been removed from the tape, since RI'store can identify the tape from its digital label. Mount will also update the tape set type (Normal, Initial, Active) and the default for the auto-remove prompt. These parameters are tape set dependent. You can override these values during a particular archive session by changing the parameters before you archive.
If the tape's external label is indiscernible, click on the mount button to determine the name of the 
tape set and the tape's number. Attach a new label with the correct information.

Mount does not need to be performed manually prior to retrieving information, however it is 
recommended since human error is minimized. If the tape number and tape set is already known 
(from the search function), then those values can be set manually and retrieve used to list the 
patients on the tape. Each archive and retrieve process mounts the tape and verifies the current 
information prior to storage or retrieval. Once the tape has been verified and is in-use by either 
the storage or retrieval functions, no other UNIX functions should use the tape device or interrupt 
the process. Although the tape device is flagged as in use during the archival of each exam, there 
is a small amount of time between the exams when the tape drive may appear to be not in use. 
Therefore, it is recommended policy to use the archive tape drives for archiving only and purchase 
other drives for UNIX operations.

E. **EJECT TAPE**

The eject tape button will eject the tape from the tape drive. This function is done prior to 
inserting a new tape for initialization or an old tape for retrieval.

To eject a tape, click on the eject tape button to remove the tape from the tape drive. To load a 
new tape, insert a new tape into the drive and gently press on the tape drive's door to close it. 
When there is no tape in the drive, the eject command may not open the drive's door. Use the 
button on the front of the drive to manually open the door.

F. **TAPE SPACE**

The tape space canvas displays the number of 
256x256x2 images that can still be stored on the tape. If 500 or more images can be stored, then 
the canvas will display green. If 250 to 500 images can be stored, the canvas will turn yellow.
And if less than 250 images can be stored, the canvas will display red to warn you that the end of 
the tape is eminent. The actual tape space is approximate, since variable data compression may be 
used, or the tape length may vary.

If the archive process reaches the end of the tape before all of the images are acquired in the 
selected study, then a tape full message will be issued. Any exams that did not fit on the tape will 
not be removed from the system or added to the archive log. Simply initialize a new tape and 
begin archiving again. If the tape space displays 0, then either the tape is full or the selected tape 
number has not been initialized yet.
G. Archive Selected Patients

The archive button opens the archive popup. This window allows the operator to select patient exams for archival and determine whether they should be removed following archival. During the archival process, each patient's exam is written to tape, followed by an exam label containing the patient's database information. When both of these files have been written without error (end of tape, bad media, power failure, ...), the exam information is added to the RI archive database. If auto-remove is on, the exam will then be removed from the disk and from the RI image database.

If an error occurs, initialize a new tape and begin again. DO NOT continue to use this tape as the media may be faulty. If it is at the end of the tape, you should begin using a new tape anyway. The UNIX interface to the tape does not always reliably differentiate between end of tape or faulty media conditions, therefore discontinue archiving to that particular tape whatever the cause may be.

The archive function should be performed at the end of each day, clearing the disk space for the following day. Even though the archive process uses very little CPU power and runs in the background, by archiving at night you free up the drive during the day to retrieve previously archived exams.

All of the patient's images, studies, print pages, annotation, window layout, and related configuration files will be archived with the patient. Exam data is stored under the system's image directory and is further compartmentalized by exam, and series. All of the information inside the selected exam's directory will be archived, including print and image window configuration files. Additional files included in this directory structure (under the unique database exam key) will be archived with the exam. A tape directory file is stored after each patient to allow the RI system to rebuild the archive database from the last tape in the series.

Although RI'store will allow you to add images to the end of any RI'store archive tape, it is best to get in the habit of archiving only on the last sequential tape in the series. This will result in a tape set which is sequential in time and after seven years (or the minimal storage time set by state law) the tapes may be discarded or moved to long term storage. Additionally, the write-protect slider should be set on old tapes so that they may not be overwritten. Even if an exam was restored recently, do not try to store it on a previous tape. By archiving the old exam on the most current tape, you can determine when exams were actually reviewed and restore the most current version.

To archive exams, perform the following:

1. Insert the last tape for the selected tape set and click on mount
2. Select the tape set name, the tape number will be set to the last tape automatically.
3. Click on the Archive button
4. The tape set type should be set automatically (Normal, Initial, Active)
5. Click on the List Patients button to update the list of patients
6. Select the patients to archive
7. The auto-remove option should be set automatically (confirm this)
8. Click on the Start Archive button

Each of these steps will be described in more detail throughout this chapter.

**Tape Set Type**

The type of tape set can be selected from this prompt, and is usually set the tape set's default value specified during the tape set creation. The normal tape set is used for single tape archives and for additional tape sets used for research or personal purposes. This type of tape set usually has the auto-remove function defaulted to off. The initial and active tape sets are used to create duplicate tape sets for security and reliability. The initial backup will archive all the unarchived exams without removing the images (auto-remove turned off). The active backup will archive only archived exams and then remove the exams. This will ensure that each patient is archived on both tape sets. To further ensure this reliability, when the initial tape set is inserted and initial is selected, only the unarchived exams will be listed for archival and auto-remove will be turned off. When the active tape set is inserted and active is selected, only those exams which have already been archived on the initial tape set and which are not locked will be listed. The auto-remove option will be turned on for the active tape sets. The exact selection criteria for the initial and active patient lists can be specified in the config popup and will be discussed later in this chapter.

**List Patients**

The list patients button will update the list of patients in the scroll list. This will add any exams that have recently been imported using RI'port. Simply click the list patients button with the left mouse button. When the archive button was clicked, it also updated this list, so the list patients button is only necessary if the patient select popup was left open for some time. Select the desired sort option to list patients in this scroll list. Also, the patients listed will depend upon the type of tape set as described in the previous section. The criteria for each patient query is specified in the config popup described later in this chapter.

**Patient Exam Selection**

A list of patient exams is shown in the patient selection scroll list. Clicking over each patient will toggle that patient as selected or not selected. If you press the left mouse button down over a patient and keep it depressed while you drag the mouse down the list, multiple patients will be selected.

RI'store will warn you when you select an exam, whether that exam is currently in-use or incomplete. **Do not auto-remove exams that are known to be in-use.** Re-import exams that are incomplete to make sure that all of the images have been transferred.

**Exam Sort Options**

The sort menu may be changed to alter the appearance of the patient selection scroll list. It is sometimes useful to list the patients by exam number to confirm that the numbers are sequential and thus, no exams are missing. A skip in sequential exams may mean that someone forgot to import the exam to the RI system.
In-Use Warning

As soon as one of the exams is selected, the in-use flag is set in the database for this exam to notify other users that your intentions are to archive and potentially remove this patient. Similarly, if you select a patient that is in-use by another RI program, RI'store will warn you where that exam is in-use. You may not want to archive patients, and you especially do not want to remove patients that are currently in-use.

If you feel that the in-use flag has been set erroneously, then verify that in fact the patient is not in-use and continue archiving it. If a program was exited incorrectly (icon quit, header quit, menu quit) rather than using the quit button, or if a patient study was not closed after the review or processing was complete, then this flag may remain set. To clear the flag, open the exam with the system and program defined by the in-use warning, and close the exam properly.

Incomplete Warning:

When an error has occurred during image import or export, the patient exam is left in an incomplete state. This may have occurred because a scanner went down, or the RI workstation was turned off during the import function. Whatever the reason, you do not want to archive an exam that is flagged as incomplete. To clear this flag, simply import the exam again. This will not write over any images that exist, however it will verify that the entire exam is complete.

RI'store will allow you to archive and auto-remove exams that are flagged as incomplete, however it makes you confirm that this is really what you want to do. It is not recommended practice to archive these exams without verifying the existence of all of the images.

Auto-Remove Option

Click on ON or OFF to enable or disable the auto-remove function. If ON is selected, each selected patient will be removed from the SUN workstation only after being successfully archived onto the tape. If OFF is selected, then the archive will be completed but the exams will not be removed from the system. This option should only be set to ON if performing a active archive.

RIview allows a physician or technologist to lock a desired exam. This is done to ensure that the patient will remain on the RI system until the lock is removed. RI'store honors this flag and will not remove any exam which has the lock set to YES. RI'store will archive that patient as if the auto-remove option were set to NO.

Archive

The start archive button does just that. It verifies that the correct tape is mounted. Then it skips to the end of the tape. When it reaches the end of the tape, it begins archiving the selected exams. After each exam is successfully added to the tape, it is added to the archive database and auto-removed if that function is enabled.

The status bar at the bottom of the RI'store main window will show the program's current status.

<table>
<thead>
<tr>
<th>Typ</th>
<th>Ser</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
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<td>Sunrise 1</td>
</tr>
<tr>
<td>MR</td>
<td>4</td>
<td>INCOMPLETE...Sunrise</td>
</tr>
<tr>
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<td>3</td>
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<tr>
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<td>5</td>
<td>Sunrise 1</td>
</tr>
<tr>
<td>MR</td>
<td>3</td>
<td>Sunrise 1</td>
</tr>
</tbody>
</table>
Chapter 9. Image Storage

5.3.01

Archive and Quit

The archive and quit button performs the same operations as the archive button, however RI'store will be quit after the archive is complete to relinquish the computer resources (memory...) to other programs.

Tape Full

If the tape does not have enough space to archive a complete patient, a message will appear showing "Tape:Full". Simply initialize a new tape and continue archiving. The patient exam will not be added to the archive database if the archive was not completed. Therefore, the archive log for the tape will be correct, even if a "tape full" error occurs.

H. ARCHIVE DATABASE

The archive database maintains patient and exam information so that the RI'store program may locate those studies at a later date. The ability to search for a patient exam based on name, identification number, exam number, or date make RI'store a powerful archive utility. Since the archive logs are maintained in the computer's database, there is no need for manual archive logs. This is required if Rational Imaging is to achieve the goal of centralized archival, where a librarian locates the exam in the computer, inserts the appropriate tape, and retrieves the patient study.

Since this database is a crucial component of the systems operational goals, it is important to maintain backups of this database. Therefore, when each tape is initialized, both the RI image database, and the RI archive database are archived onto tape immediately after the tape label. In the unfortunate event of a hard disk crash, where the database is unrecoverable. A restore database function is available which will restore the RI system databases from the last sequential tape. It will then search through the tape and update its records for each of the patients appended to the tape. While this can not ensure that the unarchived patients on the system disk will not be lost, it can ensure that the archive database maintains its integrity.

If the exams are imported from the scanners frequently, and the exams are not removed from the scanner until they are archived on tape, then the possibility of losing an exam is virtually non-existent.

Further information regarding the data maintained in this database and its relational architecture is available in the appendix.

I. LOCATE PATIENT/EXAM INFORMATION

Each patient stored on consecutive archive tapes is entered into the archive database or "computer log book". The search command allows the operator to locate a patient's images by some familiar piece of information. For example, by entering "JO" in the last name field and clicking on the search button, all of the patients whose last names begin with "JO" will be listed (Jones, Johnson...).

The first column in the search scroll list is the tape number. The archive tape set is also shown beneath the archive column header, which is followed by the tape position. When the operator
locates the desired patient's exam, he simply mount's the specified tape and retrieves the patient's information using the retrieve function. The position of the patient on the archive tape allows the exam to be located easily in the retrieve popup.

To locate a desired exam, perform the following:

1. Click on the search button to open the search popup
2. Enter the known patient information. The more information that is entered, the more the search is limited, however the search is also more prone to typing errors and misspellings.
3. Select the desired sort options
4. Click on the start search button
5. Locate the exam in the scroll list.
6. Determine the tape set, tape number, and position

**Search Fields**
The following search fields may be used to locate patient information. Each field of information entered will further limit the search as these are joined in the database query using the "AND" criteria.

**Patient Name:** This field contains the patient name which was entered during the scan. If the last name is always entered and then the first name separated by a comma, then this search will be by last name. However if the first name is entered first, then the search will be by the first name or entire name. Usually only a few characters are necessary to locate the exam.

**ID Number:** This is the patient's ID number used by the facility. You must enter the exact number.

**Exam Number:** This is the patient's exam number for the procedure. You must enter the exact number.

**Inclusive Dates:** These dates limit the database search. If you know that an exam was performed after January of 1993. Then enter 1/1/93 in the left date field. If you also know that the exam was done before November 20, 1993, then enter "11/20/93" in the right date field. Press the start search button to perform the search. The date format must be numeric and use the following format (mm/dd/yyyy or mm/dd/yy) where mm, dd, yy and yyyy are numeric values of month, day and year respectively. This option is very useful for listing the exams from a particular day to determine which exams can be removed from the scanners. Simply enter the same date in both fields to search for the exams on the desired date.

**Sort Options**
Select the appropriate sort option to apply to the list of patients. This option will be active during subsequent searches.

**Start Search**
Click on this button to apply a new search or update the list with a new sort criteria.

**Locate Exam Scroll List**
The scroll list in the search popup lists the patients which match the entered criteria. The next page of patients may be obtained using the slider on the right hand side of the scroll list. This list shows enough information to locate the desired exam. The tape set name is specified under the Archive column. The position of the exam on the tape is shown under the Pos column. The tape number is given under the Tape# column. This information is all
that is required to accurately and efficiently locate a patient's study from a centralized set of archive tapes.

Further operation details regarding scroll lists may be obtained from chapter 2.

J. **TAPE NUMBER**

The current tape number is shown in the tape number prompt. This number may be incremented by entering new values or by clicking the adjacent arrows. The retrieve button will use this field to determine which tape to list. Therefore, by incrementing this field and clicking the retrieve button, you can obtain listings of any tape. You can also print the directory of any tape in this fashion.

This tape number will be verified from the tape's digital label when the archive and retrieve functions are actually activated. If the number and tape set do not match the currently inserted tape, then a warning will be issued to enter the correct tape information.

If a tape number is entered which has not yet been initialized, then the tape space will display 0 and turn red.

K. **RETRIEVE SELECTED PATIENTS**

The retrieve function allows an operator to restore a selected patient's images and associated information back onto the RI workstation for review or additional processing. When the patient is selected and the retrieve button pressed, the RI'store program verifies that the correct tape is inserted by checking the tapes digital ID label. Then RI'store skips to the tape position where this patient is located and extracts the patient data into the archive directory. Warning: Insufficient disk space in the archive directory or the images directory can cause this portion of the program to fail.

If the wrong tape was mounted, then RI'store would retrieve the wrong patient from the selected location. Therefore, RI'store will warn the operator of this event and stop the retrieve process. If this error should occur, verify the tape's number and tape set name and if they do not represent the tape in the tape drive, enter the correct information and then begin the retrieve function again. If the tape's label is not readable or missing, use the mount button to identify the tape. Then relabel the tape.

Once the patient data is retrieved, the image and patient data is re-inserted into the patient database and its related subdirectory structure. At the end of this process, the patient information is again available to the RI system.

To retrieve a patient's exam, perform the following steps:
1. Eject the current tape
2. Insert the correct tape for this patient
3. Select the tape set name and tape number
4. Click on the retrieve button
5. Click on the exam to be retrieved
6. Click on the start retrieve button

**Tape Number**

The tape number in the retrieve popup verifies that the correct tape is being listed. You can not adjust the tape number here. Instead, enter the number on the RI'store main console and click on the retrieve button.

**Location for Retrieved Exam**

The location menu allows the operator to determine where the images will be restored to. The disk space canvas will show the available image space as this option is changed.

Similar to the RI'port location prompt, if the exam is already present on another disk, then these images will be added to that location and override this selection. However, since the purpose of retrieve is to restore patients that do not exist, it is unlikely that the exam is already present within the RI system.

Select a location where the images will actually be reviewed, or where there is sufficient disk space to fully retrieve the entire exam. Running out of disk space during retrieval will cause unpredictable results.

**Disk Space Canvas**

The available disk space is shown in this canvas to let the operator know how many 256x256x2 images can be retrieved. Select a disk location where there is sufficient disk space to retrieve the selected exams. Running out of disk space will cause unpredictable results. The color of the canvas will reflect the amount of disk space available as described on page IX-4.

**Retrieve Exam Scroll List**

The scroll list in the retrieve popup lists the patients which are located on the selected tape. The next page of patients may be obtained using the slider on the right hand side of the scroll list. This list shows enough information to locate the desired exam. It is always sorted by position on the tape so that if multiple exams are selected, they will be retrieved efficiently (sequentially). If you are having trouble locating an exam in this list, use the search button to locate the exam and determine the position from the search popup's scroll list.

Further operation details of scroll lists may be obtained from chapter 2 under Graphical User Interfaces.

**Retrieve button**

Click on the retrieve button to begin retrieving the selected exam(s).

**Retrieve and Quit button**

Click on the retrieve and quit button to begin retrieving the selected exam(s). When the exam(s) has been restored, RI'store will quit relinquishing any computer resources which were being used.

**L. VERIFY DUPLICATES**

The verify button is used to open the verify duplicate archives popup window. This window will allow the operator to perform
a weekly analysis of the dual archive integrity. The starting date should be set as the beginning date of the archive. When the configuration is saved (config button), this date will not need to be set again. Once the date has been set, click on the list button to perform the analysis. This procedure can take several minutes and should be performed at least once a week. This popup will list all of the exams which have not been archived on both the initial and active tape sets. Click the print button to print this list to the printer designated in the config popup.

If the procedures for dual tape archives are followed, then this procedure should always display a blank list. However, if someone accidentally archives an exam onto another tape and auto-remove is set to ON, then the exam may not make it to the active set. Also, if an exam is removed using RImove (not recommended), then it also may not have made it to both tapes. Finally, if a tape is destroyed and is designated as OFFSITE (non-retrievable), then this list will show all of the exams which do not have a valid duplicate archive.

It is highly recommended to make sure that EVERY exam is stored on at least 2 tapes in the event of fire, theft or other tape malfunctions. Therefore, use this feature often to ensure data validity.

M. PRINT TAPE DIRECTORY

Use the print button in the retrieve popup window to print the contents of the tape. This function can be used to keep a physical log book of the facilities tape archives. The printed tape directory is also useful as a check list to compare the days exams on the scanners and the archived exams before removing the exams from the scanner.

Enter the name of the printer in the config popup before using this feature. If the printer field of the config popup is blank, then the log will be printed to a file "TAPE_LOG" in the user's home directory.

This function is useful to send a tape to another facility and have them review the images. By printing the directory information, another RI facility can mount the foreign tape and retrieve the archived images. Additionally, since standard UNIX commands were used to archive the images, any research facility with UNIX programmers would be able to dump the images to their own foreign UNIX systems. See the section on the tape format for more information (chapter 9).

N. FOREIGN TAPES

RIs store relies upon the tape's digitally encoded labels to determine the tape set name and tape number. This information is used to list the tape log for the retrieve function. If, however, you wish to retrieve information from a tape archived at another facility, the exam log will not exist on your system. Therefore you must know the file position of the desired patient on the tape. This position is listed in the retrieve scroll list or the search scroll list of the previous system. Have the facility print the tape directory and include it with the tape cassette.

With the tape and directory information, select "Foreign" as the tape set. Then open the retrieve window and select the desired position(s) of the exams to import. The tape files contain the necessary database information so that the images can be retrieved to your system. If you archive these images on your system tapes, the exam will be added to your archive database.
Chapter 9. Image Storage

O. Configuration

The config button opens the configuration parameters popup. This popup can be used to change the default printer, the maximum patient list length, and various query criteria for the initial and active tape sets.

**Printer:**

This prompt specifies the name of the printer which is attached to the system. The name entered here must exist in the printcap file. This printer will be used to print the tape directory as described on page IX-11.

**Max List Length:**

This prompt specifies the maximum number of patients which will be listed in the query scroll list. If your query specifies any name beginning with d, and you do not enter additional query criteria, then the list will probably be enormous. Thus, this field will limit the number of patients which will actually be listed. The default for this field is 200. Increase this value if you find that during normal operation, it is insufficient to display the exam information.

**Initial:**

This prompt allows you to specify the SQL query criteria used when the initial tape type is selected. This is an added criteria, so it must begin with "and", as in the following example:

```
and archive_uk=0 and transfer=0
```

This additional selection criteria will be added during the patient list command and will thus, only list patients which have not been archived (archive_uk is null), and which have been completely transferred (transfer flag is null).

**Active:**

This prompt allows you to specify the SQL query criteria used when the active tape type is selected. This is an added criteria, so it must begin with "and", as in the following example:

```
and archive_uk>0 and lock_uk=0 and exam_date<today
```

This additional selection criteria will be added during the patient list command and will thus, only list patients which have been archived (archive_uk is not null), which have not been locked (lock user key is null), and do not have today's date (exam date less than today's date).

**Disk Units**

Use the right mouse button to select the desired disk units for the disk space gauge. Once selected, the number inside the disk space gauge will represent these units. 256x256x16 is the recommended selection for MR images. Make sure that all the programs that have a disk space gauge are configured with the same units.

**Save Configuration**

The save configuration button saves RI'store's window layout along with the values specified in the config popup. These default values are stored in the user's defaults directory in a file ".ristore5". The period beginning the file name maintains this file as a
hidden file. This file contains the defaults entered in the config window, as well as the window positions on the main screen. It also saves the current value of the tape set on the main console as a default value, so that each time RI'store is loaded, that tape set will be displayed. Details on the “.ristore5” file structure are given in the appendix under user configuration.

P. RELIABILITY ISSUES

RI'store's tape archives have been designed to optimize reliability and prevent accidental malfunction. During initialization, each tape is digitally labeled with a unique identification number, the tape set name, and the version of the tape format. The tape set and tape number enable RI'store to use the correct tape log when searching for or retrieving an exam. The software version is included for backwards compatibility in case advanced archiving techniques such as data compression are employed in the future.

During each retrieve and archive operation, the tape is mounted and the digitally labeled information is compared with the operator's request. If the operator has forgotten to change the tape set to the correct value, or has not entered the correct tape number, then the archive or retrieve function will be stopped and a warning issued to the operator.

Before each exam is archived or the database information block is written to the tape, the tape's status and position is verified to make sure that another UNIX operation has not rewound the tape or otherwise altered the tape position. If this occurs, an error message is displayed, and the archiving function stops immediately without rewinding the tape.

Additional security has been implemented in the tape's structure by archiving the entire RI system's databases onto the tape following the tape label. Additional information about this feature is presented in the archive database section of this chapter and in the RI installation manual under rebuild RI databases from tape.

Always remember to move the write-protect slider to the write protected position when each tape becomes full.

Q. DUAL TAPE ARCHIVES

The purpose of dual tape archives is to improve the reliability and security of tape backup. It is recommended to use two tape sets which are at different locations to avoid the possibility of theft or fire destroying both archives.

The initial tape archive set will be used to archive all of the days unarchived exams without removing them from the system. VERIFY THAT THE EXAMS EXIST ON TAPE PRIOR TO REMOVING THE EXAMS FROM THE SCANNERS to ensure that they have at least been archived once in the event of a hard disk failure. The initial tape backup should be done at the end of each day.

The active tape set will be used to archive and remove any archived and unlocked exams from the system after they have been reviewed and dictated, or after a predetermined time period such as 1 day.

Since the two tape sets archive completely different subsets of the exam database (archived and unarchived), and since these groups are mutually exclusive, there should be no problem in archiving to dual tape drives at the same time. The initial drive will be archiving the archived
exams, and the active drive will be archiving the unarchived exams. Thus, this protocol does not rely on close communication between the two processes and will thus be more infallible.

The active set will have the most current information and should be kept on-site for patient retrieval. The initial copy can be taken offsite to ensure security and reliability. Or if the initial copy is already at another facility, leave the tapes there for emergency access.

The following protocol has been included to simplify this process. We will call the two tape sets "Main_Hospital" and "Remote_Facility" for purposes of elucidation. The Main_Hospital archive tape set will be designated as initial and the Remote_Facility tape set will be designated as active.

### Initial Tape Archive Set - Main Hospital

1. Select the **Main Hospital workstation** with the tape drive attached at the "$\text{Run on host:} "$ prompt in the program launcher rillogin.
2. Run **ristore** on that workstation to access the tape drive there.
3. Insert the last tape and click on the **Mount button** and verify the following:
   - **Tape Set:** Initial
   - **Tape Drive:** DAT@MH
4. If the **tape space** is low, initialize a new tape
5. Click on the **Archive button** and verify the following. Do not turn on auto-remove or the exams may never be archived on the Active tape set.
   - **INITIAL selected**
   - **Auto Remove:** OFF
6. If these setting are correct, only UNARCHIVED exams will be listed.
7. Select all of the exams.
8. Click on the **Archive and Quit button**.

### Active Tape Archive Set - Remote_Facility

1. Select the **Remote_Facility workstation** with the tape drive attached at the "$\text{Run on host:} "$ prompt in the program launcher rillogin.
2. Run **ristore** on that workstation to access the tape drive there.
3. Insert the last tape and click on the **Mount button** and verify the following:
   - **Tape Set:** Active
   - **Tape Drive:** DAT@RF
4. If the **tape space** is low, initialize a new tape
5. Click on the **Archive button** and verify that the following have been set.
   - **ACTIVE selected**
   - **Auto Remove:** ON
6. If these setting are correct, only ARCHIVED, UNLOCKED exams MORE THAN 1 DAY OLD will be listed.
7. Select all of the exams, unless you want to leave some of them on the system.
8. Click on the **Archive and Quit button**.

If this protocol is followed precisely, then all exams should exist on both tape sets and be secure in the event that theft or fire should occur at one of the facilities.

Although different tape drives can be used at each facility, it is recommended that both drives be of similar type (DAT, AIT, DLT...) and manufacturer. If your network does not extend to two facilities, or if you are using a single workstation, then you can still create two tape sets, a initial
and one active, and use this same protocol. Be advised however, that the initial tapes should be taken offsite for security as quickly as reasonably possible to minimize the danger from fire or other catastrophe.

Use your judgment as to how to configure your multi-tape system, or contact our technical representatives for advice.

### Tape File Structure

Standard UNIX commands have been chosen to create these tapes improving the reliability and future supportability of the media. The first file on the tape consists of a unique tape ID label. Once this is written on the tape during the initialization process, the tape may not be initialized again. This will prevent the mistake of over-writing an archive tape during initialization. The second file on the tape consists of a backup of the *RI* image and archive database files. In the event that the hard disk fails and needs to be replaced, the archive database can be rebuilt from the last tape's directory. This function ensures the long-term reliability of this product.

The remaining tape files contain exam information. Each exam contains two files. The first file is an uncompressed tar backup of the entire exam directory. The second file is a database label for the exam. This label allows the rebuild_archive program to quickly search through the tape and determine its contents. Since a tape does not have a directory or table of contents like a magnetic or optical disk, each file must be determined sequentially from the tape. The rebuild_archive procedure will take approx. 45 minutes if the tape is full.

The following is an example of the tape's files:

<table>
<thead>
<tr>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>tape label</td>
</tr>
<tr>
<td>2.</td>
<td>tar backup of the <em>RI</em> system databases</td>
</tr>
<tr>
<td>3.</td>
<td>tar backup of exam number 1</td>
</tr>
<tr>
<td>4.</td>
<td>database info for exam number 1</td>
</tr>
<tr>
<td>5.</td>
<td>tar backup of exam number 2</td>
</tr>
<tr>
<td>6.</td>
<td>database info for exam number 2</td>
</tr>
<tr>
<td>7.</td>
<td>..</td>
</tr>
<tr>
<td>8.</td>
<td>..</td>
</tr>
<tr>
<td>2*n+1</td>
<td>tar backup of exam number n</td>
</tr>
<tr>
<td>2*n+2</td>
<td>database info for exam number n</td>
</tr>
<tr>
<td>2*n+3</td>
<td>end of media tape marker</td>
</tr>
</tbody>
</table>
Appendix A.

A. RI'PORT MAIN WINDOW

- Select Patient Button
- Drag & Drop Icon
- Source Menu Prompt
- Destination Menu Prompt
- Image Space Canvas
- Config Button
- Status Button
- Info ? Button
- Quit Button

B. PATIENT SELECTION POPUP

- List Patients Button
- List Series Button
- List Images Button
- Diag View/Tech View Option
- Transfer Button
- Transfer and Quit Button
- Patient Sort Prompt (Local only)
- Image Sort Prompt (Local only)
- Patient Select Scroll List

C. STATUS POPUP

D. INFORMATION POPUP
Appendix B.

RI’view Interface

A. RI’VIEW MAIN WINDOW

Select Patient
Tools Button
Next Window Button
Previous Page Button
Next Page Button
Info ? Button
Config Button
Save Button
Quit Button

B. PATIENT SELECT POPUP

Information Button
Lock Exam Button
Archive List Button
List Patients Button
List Series Button
List Images Button
Load Patient Exam Button
Load Print Page Button
Patient Sort Prompt
Image Sort Prompt
Patient Select Scroll List
Patient List Tabs

C. IMAGE POPUP

Image Menu
Header showing date
Footer showing ACTIVE
Pushpins
D. **TOOLS POPUP**

- Mouse Control Mode
- View MR/CT Mode
- View Xray Mode
- Text Mode
- Print Mode
- Window/Level Mode
- Regional Win/Lev Mode
- Clip Mode
- Select Mode
- Pan Mode
- Rows/Columns Menu Button
- Zoom Menu Button
- Window Control Menu Button
- Undo Menu Button
- Display Monitor Button
- Group Window Button
- Rotate Button
- Prev/Next Winlev Buttons
- Cross-reference Button
- Cine Button
- Label Image Button
- Sharpen Button
- Smooth Button

E. **TEXT OPTIONS POPUP**

- Color Prompt
- Object Type
- Text Size Menu
- Line Thickness
- Font Size
- Limit
- Font Selection
- Font Style
- Shadow

F. **PRINT OPTIONS POPUP**

- Create Button
- Delete Button
- Show Button
- Print Template Scroll List
- Print All Images Button
G. **PRINT PAGE POPUP**

- Zoom Button
- Next Print Page
- Previous Print Page
- Print Menu Button
- Copies Prompt

H. **SAVE LAYOUT POPUP**

- Reviewed Option
- Dictated Option
- Locked Option
- User Display
- Save and continue Button
- Save, print and quit Button
- Save and close Button
- Discard modifications Button

I. **CONFIG POPUP**

- Default Zoom Prompt
- Zoom Type Prompt
- Magnification Type
- Decimation Type (Reduction)
- Edge Sharpen Prompt
- Edge Smooth Prompt
- Print Zoom Prompt
- Show Pt Info
- Memory Use

- Display Warning
- Dither Color Images
- Auto Patient List
- Patient List Select
- Image Menu
- Image Display
- Layout Position
- Default Cine Speed
- Print page height default
- Copy Grease Pencil default
Appendix B. RI’view Interface

5.3.01

B-4

Image Labels Options
Teaching Application
Edit Print Template List
Edit Load Template List
Edit Window Level List
Save Configuration Button

J. WINDOW/LEVEL POPUP

Level prompt
Window prompt
Apply Button w/menu

K. CINE POPUP

Stop button
End-refere se
Reverse
Forward
Image slider
Speed slider

L. PATIENT INFORMATION POPUP

M. IMAGE INFORMATION POPUP
N. **MATCH SERIES WITH WINDOW FORMATS POPUP**

O. **LOAD TEMPLATE POPUP**

P. **SAVE LOAD TEMPLATE POPUP**
Q. **JUKEBOX RETRIEVE POPUP**

R. **INFORMATION POPUP**
Appendix C. 

RI'store Interface

A. RI'STORE MAIN WINDOW

Archive Button
Search Button
Retrieve Button
Verify Button
Import Button
Archive Set Menu Prompt
Archive Drive Menu Prompt
Mount Button
Eject Button
Initialize Button
Media # Prompt
Archive Space Canvas
Config Button
Info ? Button
Quit Button

B. ARCHIVE POPUP

List Patients Button
Patient Sort Menu Prompt
Diag View/Tech View Options
Archive Type
Auto Remove Options
Archive Button
Archive and Quit Button
Patient Scroll List

C. SEARCH POPUP

Last Name Prompt
ID Number Prompt
Exam Number Prompt
Dates (Format Mon/Day/Year)
Start Search Button
Patient Sort Menu Prompt
Archive Set Option
Patient Scroll List
D. **RETRIEVE POPUP**

- Retrieve To Menu Prompt
- Disk Space Gauge
- Tape Number Identifier
- Print Archive Log Button
- Retrieve Button
- Retrieve and Quit Button
- Patient Scroll List

E. **VERIFY POPUP**

- Starting Date
- List Button
- Print Button
- Duplicates Scroll List

F. **CONFIG POPUP**

- Printer Prompt
- Max List Length
- Initial Query Text
- Active Query Text
- Disk Space Units
- Reset Archive Drive Button
- Save Config Button

G. **INFORMATION POPUP**
Appendix D. **RI'login Interface**

### A. **RI'LOGIN MAIN WINDOW**
- Login Button
- Print Tool Button
- Save Config Button
- Lock Screen Button
- Information Button
- Logout Button
- Hide/Show Icons Button
- Run on host Prompt
- Disk Space Canvas
- Program Icons

### B. **LOGIN POPUP**
- Username Prompt
- Password Prompt
- Database Access Menu
- Accept Button

### C. **PROGRAMS POPUP**
- Program Icons
**D. SAVE CONFIG POPUP**

- User Warning Prompt
- Host Warning Prompt
- Update disk space Prompt
- Disk Space Units
- Icon colors (RGB)
- Save Defaults Button

![Save Configuration Popup]

**E. INFORMATION POPUP**

![Information Popup]

**RATIONAL IMAGING**
**Rl'tlogin**
**Version 6.0.0h**

User: Imaging  
Host: equinox  
Database: radiology

Intuitive Software Technology  
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Appendix E. User Customization

A. Definitions

Each user can have his/her own defaults directory as specified in the users table. User configuration files exist in each user's defaults directory. These files are hidden files (begin with a period ".") and are usually referenced by the program they refer to. For example, the ".riport4" file saves the configuration parameters for the RI'port program. The following sections describe the elements contained in these configuration files for the RI'port, RI'view, and RI'store applications.

These files are ASCII and can be edited using the standard text editor in the DeskSet applications provided by Sun (textedit). These files are also updated when the save configuration button is pressed within each application.

B. RI'port

The following parameters can be found in the .riport4 file. These parameters specify the size and location of each of the windows and popups within the RI'port application. If you always want RI'port to be displayed in the upper left corner of the screen, then move it there and save the configuration. The values in the .riport4 file in your defaults directory will be changed accordingly. Each user can specify his/her own configurations provided they do not share the defaults directory.

The following information is contained in the ".riport4" file in the user's defaults directory.

```
RIPORT DEFAULTS Version 2.2
430 2 riport = x, y, width, height, window name
306 184 list_pat1
555 187 information
2 0 = disk units selection, default compression
117 240 status = x, y, width, height, window name
```

C. RI'view

The following parameters can be found in the .riview7 file. These parameters specify the size and location of each of the windows and popups within the RI'view application. If you always want RI'view to be displayed in the upper left corner of the screen, then move it there and save the configuration. The values in the .riview7 file in your defaults directory will be changed accordingly. Each user can specify his/her own configurations provided they do not share a defaults directory.
The first eleven lines must appear in the order shown. The remaining lines can be ordered so that the items will appear in the menus the way you desire. Maybe you want the items sorted alphabetically, or put the most frequently used options at the top of the menu.

**Configuration Parameters**

```
RIVIEW DEFAULTS Version 2.11
229  0  riview  =x, y, width, height, window name
20  75  list_img1
631  25  config
565  25  information
0  0  tools
707  0  print
81  0  printwin
706  45  text
579  88  pt_flags
0  0  winlev
0  0  pt_info
0  0  img_info
0  0  cine
0  1  0  1  4  10  9  1  1  1  1  800 1 1.3 Canon PFI
200  0  0  0  0
81  445 remote  =x, y, width, height, window name
133  45 format
1
50  160 lock  =x, y, width, height, window name
82  100 loadtmp
98  303 savetmp
1 10 0 0
82  100 jukepop
1
No application defined…
4 0 0 1
5 25 calibpop  =x, y, width, height, window name
1.0
```

The config popup default parameters in the 15th line contains the default prompt and menu options for the config popup. These values are in order:

1. Magnifying Glass Zoom (0=2, 1=3)
2. Zoom Type (0=replication, 1=interpolation)
3. Edge Enhance Filter (0=mild, 1=strong)
4. Smoothing Filter (0=mild, 1=strong)
5. Print Zoom (0=1.05, 1=1.1, 2=1.2, 3=1.3, 4=1.4, 5=1.5, 6=1.6, 7=1.8, 8=2.0)
6. Default Speed (frames per second)
7. Image Labels (1=numbers, 2=location, 4=winlev, 8=RAS, 0=none, 15=all)
8. Text size (0=12, 1=16, 2=20, 3=24, 4=28, 5=32, 6=36, 7=40)
9. Line Thickness in Text Options Popup
10. Patient Select Load Type (Auto Prepare=0, Fast Load=1)
11. # of Print Copies
12. Print page height (pixels)
13. Text color (0=white, 1=yellow, 2=cyan, 3=black, 4=red, 5=green)
14. Monitor Gamma (1.3 default)
15. Printer name (must exist in the database table "printers")

The parameters in the 16th line are as follows:
1. Printer resolution in dots per inch (50-400)
2. Show patient info
3. Memory mode
4. Image sort criteria
5. Decimate Algorithm Default

The parameters in the 19th line are as follows:
1. Copy Grease Pencil Default Value

The parameters in the 23rd line are as follows:
1. Find Ruler
2. Default Lock Days in the lock popup
3. Display Warning if images not displayed
4. Offset Overlap in the apply load template popup

The parameters in the 25th line are as follows:
1. Image Location Default for retrieve in the Jukebox Popup

The parameters in the 26th line are as follows:
2. Teaching Applications

The parameters in the 27th line are as follows:
1. Current Line Type in the Text Popup
2. Cine Loop Type (Series/Image) in the Cine Popup
3. Cine Time (Minute/Second) in the Cine Popup
4. Dither Color Default

The parameters in the 29th line are as follows:
1. Grid cm default size for calibration

The parameters in the 30th line are as follows:
1. Hist Popup location

The parameters in the 31th line are as follows:
1. Auto Patlist
2. Patlist Option
3. Load on Exit
4. Large Icons

Print Templates

The print templates are stored in the .riview_P file in the user’s defaults directory. This file specifies which print templates will be listed in the print templates menu in riview.

PRINT TEMPLATES
mr_abdomen4
mr_abdomen6
mr_ankle6
mr_brain4
mr_brain6

The names of the print template files are also abbreviated. The actual files that need to exist in the user's defaults directory must be preceded by ".ri" and end in ".prn". For example, the "brain_mr" template must exist as ".ribrain_mr.prn".

Load Templates

The load templates are stored in the .riview_L file in the user’s defaults directory. This file specifies which load templates will be listed in the load format menu in riview.

LOAD TEMPLATES
MR_Abdomen
Appendix E. User Customization

5.3.01

MR_Angio
MR_Ankle
MR_Brain
CT_Brain

The names of the load format files are abbreviated so that they will appear this way in the format menu. The actual files that need to exist in the user's defaults directory must be preceded by ".ri" and end in ".lod". For example, the "CT_Brain" template must exist as ".riCT_Brain.lod".

**Window Level Parameters**

The window/level parameters are stored in the .riview_W file.

**WINDOW/LEVEL SETTINGS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT_Brain_BONE</td>
<td>2000</td>
<td>600</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CT_Orbit_BONE</td>
<td>4000</td>
<td>500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CT_Sinus_BONE</td>
<td>4000</td>
<td>500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Auto_MR</td>
<td>96</td>
<td>49</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Auto_MR_2E</td>
<td>96</td>
<td>49</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Auto_NM</td>
<td>101</td>
<td>50</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

These values consist of the following:

1. WinLev Description
2. Window Value
3. Level Value
4. Type of WinLev
   - 0 = Greyscale
   - 1 = Percent by Series
   - 2 = Percent by Image
   - 3 = Histogram by Series
   - 4 = Histogram by Image
   - 5 = Pseudo Color
   - 6 = True Color
5. Number of Echos to calculate individually

**D. RI'STORE**

The following parameters can be found in the ".ristore5" file. These parameters specify the size and location of each of the windows and popups within the RI'store application. If you always want RI'store to be displayed in the upper left corner of the screen, then move it there and save the configuration. The values in the .ristore5 file in your defaults directory will be changed accordingly. Each user can specify his/her own configurations provided they do not share a defaults directory.

**RISTORE DEFAULTS Version 2.8**

<table>
<thead>
<tr>
<th>Value 1</th>
<th>Value 2</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>357</td>
<td>0</td>
<td>restore = x, y, width, height, window name</td>
</tr>
<tr>
<td>0</td>
<td>260</td>
<td>list_pat</td>
</tr>
<tr>
<td>459</td>
<td>203</td>
<td>config</td>
</tr>
<tr>
<td>494</td>
<td>203</td>
<td>information</td>
</tr>
<tr>
<td>607</td>
<td>2600</td>
<td>retrieve</td>
</tr>
<tr>
<td>260</td>
<td>260</td>
<td>search</td>
</tr>
<tr>
<td>290</td>
<td>270</td>
<td>verify</td>
</tr>
<tr>
<td></td>
<td></td>
<td>canon = default printer (must be in printcap)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 200 = default tape set (0..n-1), max number of lines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and archive_uk=0 and transfer=0 = initial query</td>
</tr>
</tbody>
</table>
and archive_uk>0 and lock_uk=0 and exam_date<today = active query
7/1/92 2 0 = verify start date, disk units, default disk location
2 60 jukeretrieve = x, y, width, height, window name

E. **RI'LOGIN**

The following parameters can be found in the ".rilogin4" file. These parameters specify the size and location of each of the windows and popups within the RI'login application. If you always want RI'login to be displayed in the upper left corner of the screen, then move it there and save the configuration. The values in the .rilogin4 file in your defaults directory will be changed accordingly. Each user can specify his/her own configurations provided they do not share a defaults directory.

**RILOGIN DEFAULTS Version 2.7**

<table>
<thead>
<tr>
<th>Value 1</th>
<th>Value 2</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>640</td>
<td>0</td>
<td>rilogin</td>
</tr>
<tr>
<td>1072</td>
<td>0</td>
<td>programs</td>
</tr>
<tr>
<td>388</td>
<td>28</td>
<td>login</td>
</tr>
<tr>
<td>841</td>
<td>155</td>
<td>info</td>
</tr>
<tr>
<td>460</td>
<td>225</td>
<td>config</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>warnuser, warnhost (0=Yes, 1=No)</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>64 128 196 = Update time (min), disk space units, red, green, blue</td>
</tr>
</tbody>
</table>

The program order in the programs popup of rilogin is determined in the config popup. The program list is saved in “.rilogin_P” in the defaults directory. Each workstation can be configured to have different programs available by copying this file to the /opt/ISTri/bin directory. This file will take precedence over one in the user’s directory.

riview
ristore
riport
rimove
rilocate
ricall

The auto-login capability can be activated on a selected host by creating the following file “/opt/ISTri/bin/rilogin_L”. The presence of this file will allow auto-login in RIlogin.

To activate auto-logout, enter 2 values in this file: 1) Inactivity time (minutes), 2) Warning time (minutes). The system will auto-logout if there has been no keyboard or mouse activity for INACTIVITY_TIME + WARNING_TIME. If the warning time is non-zero, then a popup will appear notifying the user of a pending logout.
Appendix F. Load Format Files

A. DESCRIPTION

Load format files are ascii based files in the user's defaults directory which specify default parameters defining the display of a particular exam. These are user configurable and may be edited using the textedit application provided by Sun in the DeskSet Applications. Additional load formats may be added to the user's defaults directory for unlimited flexibility.

To add a new load format file, follow the specifications below in creating the file. Add the name of the load format to the .riview3 file in your defaults directory. Then name the format file by adding ".ri" before the name and a ".lod" after the name. For example, a menu option of "MR_Ankle" would appear in .riview3 as "Format MR_Ankle", and the file would be named ".riMR_Ankle.lod". UNIX is sensitive to upper and lowercase characters, so be very specific when creating these names.

The following examples demonstrate the simplicity and power of these templates. The min and max items are determined from the window and level parameters as follows:

\[
\begin{align*}
\text{min} &= \text{level} - \left(\frac{\text{window}}{2}\right) \\
\text{max} &= \text{level} + \left(\frac{\text{window}}{2}\right)
\end{align*}
\]

RI'view will first try to match the series number with a value in the first column of the load format file when creating the display layout. If the series number does not exist in the file, RI'view will use the parameters found under the 0 series number at the end of the file. Always leave this series number at the end for proper function of the template.

Each line in the load format file contains a set of parameters which will be used to display a particular series. The values in each one of the columns are as follows:

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>series number, multiple series numbers in subsequent rows specify duplicate windows</td>
</tr>
<tr>
<td>2</td>
<td># columns</td>
</tr>
<tr>
<td>3</td>
<td># rows</td>
</tr>
<tr>
<td>4</td>
<td>x clipping location within image (0.0 = left side of image)</td>
</tr>
<tr>
<td>5</td>
<td>y clipping location within image (0.0 = top of image)</td>
</tr>
<tr>
<td>6</td>
<td>width of clipping region (1.0 = entire width, range=&gt;0.0, &lt;=1.0)</td>
</tr>
<tr>
<td>7</td>
<td>height of clipping region (1.0 = entire height, range=&gt;0.0, &lt;=1.0)</td>
</tr>
<tr>
<td>8</td>
<td>magnification factor (1.0 = No magnification, range=&gt;0.0, &lt;=10.0)</td>
</tr>
<tr>
<td>9</td>
<td>min intensity</td>
</tr>
<tr>
<td>10</td>
<td>max intensity</td>
</tr>
<tr>
<td>11</td>
<td>min intensity for even images</td>
</tr>
<tr>
<td>12</td>
<td>max intensity for even images</td>
</tr>
<tr>
<td>13</td>
<td>min intensity if 3 echo sequences are acquired</td>
</tr>
<tr>
<td>14</td>
<td>max intensity if 3 echo sequences are acquired</td>
</tr>
<tr>
<td>15</td>
<td>default clipping aspect ratio</td>
</tr>
<tr>
<td>16</td>
<td>x location of window on workspace (0 is the left side of the workspace)</td>
</tr>
<tr>
<td>17</td>
<td>y location of window on workspace</td>
</tr>
<tr>
<td>18</td>
<td>Screen Number for the window (0-4)</td>
</tr>
</tbody>
</table>

The Annotate Line specifies the series description to match with other exams:
The WinLev Line specifies default window level algorithms and values as follows:

1) WinLev
2) Series Number
3) Duplicate Window number
4) WinLev Type (0=Greyscale, 1=PercentSeries, 2=PercentImage, 3=HistSeries, 4=HistImage, 6=PseudoColor)
5) Number of Echoes to calculate individually
6) Current Echo Number (information on this line pertains to 1 of the N echos
7) Minimum Intensity
8) Maximum Intensity
9) WinLev Description

An example of WinLev settings is taken from the “.riMR_SingleImage.lod” which is as follows:

```
load_template riview 1.2
1 1 1 0.00 0.00 1.00 1.00 320.00 0 0 0 0 0 0 1.0 228 100 0
WinLev 1 0 3 2 1 1 99 AutoMR_2E
WinLev 1 0 3 2 2 1 99 AutoMR_2E
2 1 1 0.00 0.00 1.00 1.00 320.00 0 0 0 0 0 0 1.0 562 100 0
WinLev 2 0 3 2 1 1 99 AutoMR_2E
WinLev 2 0 3 2 2 1 99 AutoMR_2E
(WinLev ser# dup# Typ=Hist #Echoes EchoNum Min Max Name)
```

A min of 1 and max of 99 means that 1% of the pixels will be dropped from the bottom and top of the image histogram. This should alleviate any artifacts from affecting the image quality unless the artifacts have greater than 1% of the image pixels. If you want a histogram applied on a per-image basis, then change parameter #4 (Typ=Hist=3) to 4. In the WinLev popup, you will see that the Type menu has "Histogram of Image" in position 5 which (starting at 0 0/1/2/3/4) makes this type=4. This will adjust the intensity of image based on the histogram for only that image and will exclude 1% at the top and bottom. I also would eliminate the double echo parameters requiring 2 lines. This will reduce the entry to:

```
load_template riview 1.2
1 1 1 0.00 0.00 1.00 1.00 320.00 0 0 0 0 0 0 1.0 228 100 0
WinLev 1 0 4 1 1 1 99 HistByImg
WinLev 2 0 4 1 1 1 99 HistByImg
```

The enumerated WinLev types are as follows:

0 Greyscale
1 Percent by Series
2 Percent by Image
3 Histogram by Series
4 Histogram by Image
5 Real Color (not implemented yet for w/l operation)
6 Pseudo Color

You can manually edit the .riMR_SingleImage.lod or other load template and apply these window/level parameters. Make sure to change the series number to reflect the correct series in the line above. If there are duplicate windows, then the dup# will also need to be adjusted.
B. **CT EXAMPLE**

```
load_template riview 1.2
ANNOTATE 1 Localizer
1 1 1 0.00 0.00 1.00 1.00 256 0 0 0 0 0 1.0 84 386 0
WinLev 1 0 0 1 1 -500 1500 CT_Bone
WinLev 1 0 0 1 1 -215 285 CT_Tissue
ANNOTATE 2 Upper Left
2 1 1 0.0 0.0 1.0 1.0 512 0 0 0 0 0 1.0 224 100 0
WinLev 2 0 0 1 1 -500 1500 CT_Bone
WinLev 2 0 0 1 1 -215 285 CT_Tissue
ANNOTATE 3 Upper Right
3 1 1 0.0 0.0 1.0 1.0 512 0 0 0 0 0 1.0 750 100 0
WinLev 3 0 0 1 1 -500 1500 CT_Bone
WinLev 3 0 0 1 1 -215 285 CT_Tissue

This template produces the following results when CT series 1 & 2 are loaded.
```
Appendix G.  Print Templates

A. DESCRIPTION

Print templates determine the default layout of the printed page, including such items as: 1) image location and size, 2) text, 3) arrows, 4) background colors, 5) image annotation, 6) paper size, and 7) margins.

All of the measurement values specified in the print templates are given in \( \frac{1}{100} \)th of an inch. For example, a width of 250 would result in an output width of 2½ inches.

The first line in a print template contains the following identification:

\[ \text{print_template} \text{ riview 1.2} \]

The second line in a print template contains the following columns:
1) number of image locations
2) total width of the print page area
3) total height of the print page area
4) margin (value used for each side)
5) paper size (letter, 11x17, ledger)

The following \( n \) lines specify \( n \) image locations whose columns contain the following:
1) x offset of image (upper left)
2) y offset of image (upper left)
3) width of image
4) height of image

The rest of the template is freeform with **keywords** in the first column specifying the information in that line. There are 9 types of information which can be added to the template. Each type of information MUST begin with the appropriate identifier.

Unless otherwise specified, the format of each entry is as follows:
1) Identifier
2) x location (offset to left side of name)
3) y location (offset to bottom of name)
4) color of text as described above. (0-5 acceptable)
5) Size of text in points

The color of the items is specified as one of 7 colors except for background. Background colors will be described in the following sections. The seven colors used for the other items are as follows:
0) White
1) Yellow
2) Cyan
3) Black
4) Red
5) Green
6) RED (used for Temporary Exam Vocabulary only)

Each item included requires the following information:

**Patient**

"PATIENT 5 20 1 15" will specify where to put the patient name and what attributes to give it.

**Id**

"ID 300 20 1 15" will specify where to put the patient identification number and what attributes to give it.

**Study**

"STUDY 460 20 1 15" will specify where to put the patient's exam or study number and what attributes to give it.

**Date**

"DATE 670 20 1 15" will specify where to put the exam date and what attributes to give it.

**CurrentDate**

"CURRENTDATE 40 20 3 15" will specify where to put the current date and what attributes to give it.

**Referring**

"REFERRING 40 20 3 15" will specify where to put the name of the referring physician and what attributes to give it.

**Age**

"AGE 40 20 3 15" will specify where to put the patient’s age and what attributes to give it.

**Gender**

"GENDER 40 20 3 15" will specify where to put the patient’s gender and what attributes to give it.

**History**

"HISTORY 40 20 3 15" will specify where to put the exam history and what attributes to give it.

**ExamDesc**

"EXAMDESC 40 20 3 15" will specify where to put the exam description and what attributes to give it.

**Facility**

"FACILITY 40 20 3 15" will specify where to put the name of the hospital or facility and what attributes to give it.

**FOV**

"FOV 40 20 1 16 ****~0~~~~" will specify the image field of view.
Appendix G. Print Templates

DEPTH
"DEPTH 40 20 1 16 ****~0~~~" will specify the image pixel depth.

SPACE
"SPACE 40 20 1 16 ****~0~~~" will specify the space between each image.

QRS
"QRS 40 20 1 16 ****~0~~~" will specify the time between each image.

KVP
"KVP 40 20 1 16 ****~0~~~" will specify the acquisition kVp.

MA
"MA 40 20 1 16 ****~0~~~" will specify the acquisition mA.

ECHO
"ECHO 40 20 1 16 ****~0~~~" will specify the MR echo number.

DIMEN
"DIMEN 40 20 1 16 ****~0~~~" will specify the image dimensions (512x512).

RAS
"RAS 40 20 1 16 ****~0~~~" will specify the RAS parameter (L\F).

riRAS_LEFT
"riRAS_LEFT 40 20 1 16 ****~0~~~" will specify the left side RAS orientation.

riRAS_RIGHT
"riRAS_RIGHT 40 20 1 16 ****~0~~~" will specify the right side RAS orientation.

riRAS_TOP
"riRAS_TOP 40 20 1 16 ****~0~~~" will specify the top side RAS orientation.

riRAS_BOTTOM
"riRAS_BOTTOM 40 20 1 16 ****~0~~~" will specify the bottom side RAS orientation.

RULER
"RULER 60 900 300 900 1 50 0" will specify a horizontal ruler (=50) with color 1 and line thickness 0 (x1, y, x2, y, color, type, thickness).

RULER
"RULER 60 60 60 300 1 51 2" will specify a vertical ruler (=51) with color 1 and line thickness 2 (x1, y, x2, y, color, type, thickness).

XPage
"XPage 40 20 3 15" will specify where to put the page information and what attributes to give it. This type will print “page i of n” where i is the current print page, and n is the total number of print pages.
Numbers

"Numbers 5 15 0 12" will specify where to put the image numbers over each image and what attributes to give it. The information required is as follows:
1) Numbers Identifier
2) x location (from upper left corner of image to left side of text)
3) y location (from upper left corner of image to bottom of text)
4) color of text as described above. (0-5 are acceptable)
5) Size of text in points

WinLev

"Winlev 5 27 1 12" will specify where to put the window and level information over each image and what attributes to give them. The information required is as follows:
1) Window Identifier
2) x location (from upper left corner of image to left side of text)
3) y location (from upper left corner of image to bottom of text)
4) color of text as described above. (0-5 are acceptable)
5) Size of text in points

Location

"Location 5 39 1 12" will specify where to put the image location over each image and what attributes to give it. The information required is as follows:
1) Location Identifier
2) x location (from upper left corner of image to left side of text)
3) y location (from upper left corner of image to bottom of text)
4) color of text as described above. (0-5 are acceptable, or –1 means do not set)
5) Size of text in points (if color is –1, do not set default size)
6) Size of line in points
7) Demographic page (if 1, print even though no images are on the page)

Text

"Text 0 72 6 16 Text to display~0~Prefix~Suffix~" is an example of a text entry. The following information is obtained from such a command:
1) Text Identifier
2) x location (offset to left side of text)
3) y location (offset to bottom of text)
4) color of text as described above. (6=Temporary Exam Vocabulary)
5) Size of text in points
6) Text to insert (everything to the end of the line will be included)
7) Type of text (Combinations of bits 1-2, and 3-6 may be used)
   0 = Left Alignment
   1 = Center Alignment
   2 = Right Alignment
   4 = Text Item
   8 = Checkbox Off Item
  16 = Menu Item
  32 = Checkbox On Item
   8) Prefix to text
   9) Suffix to text
Background

"Background 0 100 0 0 0 750 25" is an example of a text entry. The following information is obtained from such a command:

1) Background Identifier
2) Cyan Percentage (0-100)
3) Magenta Percentage (0-100)
4) Yellow Percentage (0-100)
5) Black Percentage (0-100)
6) x location of background (from left)
7) y location of background (from top)
8) width of background
9) height of background

B. MR 2x3 Example

print_template riview 1.2
6 850 1100 50 letter -1 0 0 0
5 25 370 315
375 25 370 315
5 340 370 315
375 340 370 315
5 655 370 315
375 655 370 315
TEXT 10 65 6 16 AXIAL~0~~~
TEXT 10 80 6 16 CORONAL~0~~~
TEXT 10 95 6 16 SAGITTAL~0~~~
TEXT 10 145 6 16 RIGHT~0~~~
TEXT 10 127 6 16 LEFT~0~~~
PATIENT 5 20 3 20 riPATNAME~0~~~
DATE 630 20 3 20 riDATE~0~~~
TEXT 235 995 3 25 SELECTED MR IMAGES~0~~~
TEXT 330 20 3 20 ID#~0~~~
ID 365 20 3 20 riID~0~~~
NUMBERS 5 15 0 12 ****~0~~~
BACKGROUND 0 0 100 0 0 750 25
BACKGROUND 0 0 100 0 0 970 750 30
BACKGROUND 0 0 100 0 0 0 1 1000
BACKGROUND 0 0 100 0 745 0 1 1000
BACKGROUND 0 0 100 4 0 1 1000
BACKGROUND 0 0 100 0 749 0 1 1000
Appendix H. Database Architecture

The database is broken up into several relational tables. Each table and the variables associated with it will be specified in this section. Since the database platform is a commercial platform supporting structured query language (SQL), it is possible to extract data from the database and perform queries from independent software. This section is provided to open the architecture and support independent query. Since these tables may be changed to support future features, use risetup in the /opt/ISTri/admin directory to obtain a current listing.

A. DATABASE TABLES

### Exam Component of the Clinical Database

<table>
<thead>
<tr>
<th>Patient</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pat_key</td>
<td>serial 4</td>
<td>unique sequential patient key</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>pat_name</td>
<td>char 28</td>
<td>patient name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>pat_no</td>
<td>char 12</td>
<td>patient id number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>weight</td>
<td>short 2</td>
<td>weight in pounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>height</td>
<td>short 2</td>
<td>height in inches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>age</td>
<td>short 2</td>
<td>age in years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>sex</td>
<td>char 1</td>
<td>sex [M,F,U]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>dob</td>
<td>date 4</td>
<td>Date of Birth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>getfromtape</td>
<td>short 2</td>
<td>Internal archiving value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>ssn</td>
<td>char 16</td>
<td>Social Security Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>private</td>
<td>short 2</td>
<td>VIP exam (1=Y, 9=No)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>exam_key</td>
<td>serial 4</td>
<td>unique sequential exam key</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>pat_key</td>
<td>int 4</td>
<td>relational link to patient table</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>exam_no</td>
<td>int 4</td>
<td>patient’s exam number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>n_series</td>
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<td>number of series</td>
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<td>relational link to exam_desc table</td>
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<td>date of exam</td>
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<td>exam modality (MR, CT, US, NM...)</td>
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<td>transfer</td>
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<td>status of image transfer (0=complete)</td>
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<td></td>
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<td>21</td>
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<td>Description</td>
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<td>------</td>
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<td>char</td>
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<td>brief history of patient</td>
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<td>Time exam was acquired</td>
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<td>Date exam was imported to PACS</td>
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<td>Time exam was imported to PACS</td>
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<td>26.</td>
<td>age</td>
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<td>Age of patient at time of exam</td>
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<td>27.</td>
<td>age_mod</td>
<td>char</td>
<td>1</td>
<td>Age modifier (y/m/d)</td>
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<td>Date the exam will be unlocked</td>
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<td>29.</td>
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<td>Has the exam been altered (saved)?</td>
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<tr>
<td>30.</td>
<td>priority</td>
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<td>Stat exam (1=Yes, 9=No)</td>
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<td>31.</td>
<td>last_access</td>
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<td>Date of last exam access (review).</td>
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<td>32.</td>
<td>accession</td>
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<td>Exam accession number from RIS</td>
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<td>33.</td>
<td>ris_status</td>
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<td>2</td>
<td>Reconciled with RIS worklist? (0=No, 1=Yes)</td>
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**Series**

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<td>unique sequential series key</td>
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<td>relational link to series table</td>
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<td>series number</td>
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<td>number of images</td>
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<td>6.</td>
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<td>image type (GE,Raster,Gif,Tiff)</td>
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<td>7.</td>
<td>orient</td>
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<td>image orientation (Ax,Sag,Cor,Obl)</td>
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<td>8.</td>
<td>psdname</td>
<td>char</td>
<td>16</td>
<td>MR pulse sequence name</td>
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<td>9.</td>
<td>operator</td>
<td>char</td>
<td>4</td>
<td>Technologist’s initials</td>
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<td>10.</td>
<td>coil</td>
<td>char</td>
<td>16</td>
<td>Name of the MR coil used</td>
</tr>
<tr>
<td>11.</td>
<td>contrast</td>
<td>short</td>
<td>2</td>
<td>Contrast used in this series (1=Yes)</td>
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<tr>
<td>12.</td>
<td>sub_series</td>
<td>char</td>
<td>1</td>
<td>Series number modifier (a/b/c…)</td>
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**Image**

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<td>ser_key</td>
<td>int</td>
<td>4</td>
<td>relational link to series table</td>
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<tr>
<td>3.</td>
<td>img_no</td>
<td>int</td>
<td>4</td>
<td>image number</td>
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<td>4.</td>
<td>tr</td>
<td>real</td>
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<td>MR relaxation time in usec</td>
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<td>5.</td>
<td>te</td>
<td>real</td>
<td>4</td>
<td>MR echo time in usec</td>
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<tr>
<td>6.</td>
<td>location</td>
<td>real</td>
<td>4</td>
<td>image location in cm</td>
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<tr>
<td>7.</td>
<td>qrs</td>
<td>real</td>
<td>4</td>
<td>image acq time relative to qrs complex</td>
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<td>8.</td>
<td>window</td>
<td>short</td>
<td>2</td>
<td>image window or contrast</td>
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<tr>
<td>9.</td>
<td>level</td>
<td>short</td>
<td>2</td>
<td>image level or brightness</td>
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<tr>
<td>10.</td>
<td>r_ctr</td>
<td>real</td>
<td>4</td>
<td>center right-left coordinate</td>
</tr>
<tr>
<td>11.</td>
<td>a_ctr</td>
<td>real</td>
<td>4</td>
<td>center anterior-posterior coordinate</td>
</tr>
<tr>
<td>12.</td>
<td>s_ctr</td>
<td>real</td>
<td>4</td>
<td>center superior-inferior coordinate</td>
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<tr>
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<td>thick</td>
<td>real</td>
<td>4</td>
<td>slice thickness in mm</td>
</tr>
<tr>
<td>14.</td>
<td>space</td>
<td>real</td>
<td>4</td>
<td>spacing in mm (=thickness+gap)</td>
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<td>real</td>
<td>4</td>
<td>horizontal pixel size in mm/pixel</td>
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<tr>
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<td>y_pixsiz</td>
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<td>4</td>
<td>vertical pixel size in mm/pixel</td>
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<tr>
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<td>width</td>
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<td>2</td>
<td>image width in pixels</td>
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<tr>
<td>18.</td>
<td>height</td>
<td>short</td>
<td>2</td>
<td>image height in pixels</td>
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<tr>
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<td>depth</td>
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<td>2</td>
<td>image depth in bits</td>
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<td>compress</td>
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<td>2</td>
<td>image compression flag (1=none)</td>
</tr>
<tr>
<td>21.</td>
<td>ti</td>
<td>real</td>
<td>4</td>
<td>MR inversion time in usec</td>
</tr>
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<td>22.</td>
<td>fov</td>
<td>real</td>
<td>4</td>
<td>field of view in cm</td>
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<tr>
<td>23.</td>
<td>venc</td>
<td>short</td>
<td>2</td>
<td>MR velocity encoding in cm/sec</td>
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<td>flip</td>
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<td>2</td>
<td>MR flip angle in degrees</td>
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<td>25.</td>
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<td>4</td>
<td>right-left normal vector</td>
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<td>real</td>
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<td>anterior-posterior normal vector</td>
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<tr>
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<td>s_norm</td>
<td>real</td>
<td>4</td>
<td>superior-inferior normal vector</td>
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<tr>
<td>28.</td>
<td>postn</td>
<td>short</td>
<td>2</td>
<td>patient position (supine, head first)</td>
</tr>
<tr>
<td>29.</td>
<td>r_tl</td>
<td>real</td>
<td>4</td>
<td>top left RL coordinate</td>
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<tr>
<td>30.</td>
<td>a_tl</td>
<td>real</td>
<td>4</td>
<td>top left AP coordinate</td>
</tr>
</tbody>
</table>
Appendix H. Database Architecture

31. s_tl real 4 top left SI coordinate
32. nex real 4 MR number of excitations
33. r_tr real 4 top right RL coordinate
34. a_tr real 4 top right AP coordinate
35. s_tr real 4 top right SI coordinate
36. kvp integer 4 CT kvp used
37. ma integer 4 CT ma used
38. tilt real 4 CT tilt
39. table ht real 4 CT table ht
40. file_no int 4 Image extension number (RI.#)
41. file_offset int 4 Byte location of image in this file
42. orig_width short 2 Width of acquired image
43. orig_height short 2 Height of acquired image
44. plane short 2 Plane of image (Like series orientation)
45. pt_orient char 8 Patient orientation DICOM (et: L\F)
46. img_time datetime 8 Time image was acquired “12:24:336”.
47. cassette_size char 16 Size of a acquisition devices detector (14INX17IN)
48. photointerp short 2 Photometric Interpretation (if 1, Invert the image)

Examlist
1. exam_key serial 4 unique sequential key
2. examtext char 128 Text used in patient display under Referring Selection
3. exam_no char 16 Exam_no (see exam)
4. exam_date date 4 Date of exam (see exam)
5. modality short 2 modality (see exam)
6. pat_name char 16 pat_name (see exam)
7. refer char 16 referring (see refer)
8. refer_key int 4 referring (see refer)
9. dictate_uk int 4 User who performed dictation (see exam)
10. direc char 16 Exam directory (see imagedir)
11. dir_key int 4 Exam directory key (see imagedir)
12. scanr char 16 Scanner (see exam)
13. host_key int 4 Scanner (see exam and host)
14. descr char 28 Exam description (see exam)
15. import_date date 4 Date exam was imported (see exam)
16. examtextloc char 128 Text used in patient display under Location Selection
17. private short 2 VIP exam
18. priority short 2 STAT exam?
19. pat_key int 4 Link to patient table with pat_key
20. altered short 2 Exam was altered (saved)?
21. archive_uk short 2 Archived number of times? (0, 1, 2)
22. desc_key int 4 Link to exam description
23. hosp_key int 4 Link to hospital table
24. use_user int 4 Link to user if in-use
25. lock_uk short 2 Is the exam locked?
26. prepare_uk short 2 Has the exam format been saved?
27. transfer short 2 Is the exam complete, or still being transferred? 
   (0=Complete)

Patlist
1. pat_key int 4 Unique patlist ID (linked to patient table)
2. pat_name char 22 Short name of patient
3. pat_no char 12 Patient Medical Record Number (MRN)
4. sex char 1 Patient gender (M, F, O)
5. private short 2 Is the patient a VIP (requires privacy)
6. text char 71 Patient list text for the RIdisplay patient selection popup.

AuthGroup
### Appendix H. Database Architecture

#### 1. key serial 4 Unique authorization group ID (linked to authgroup in users)
#### 2. groupname char 32 Name of the group (Radiologist, Administrator…)
#### 3. deleteexam short 2 Permission to delete an exam
#### 4. jukemaint short 2 Permission to Stop/Reset the jukebox
#### 5. archive short 2 Permission to archive exams
#### 6. retrieve short 2 Permission to retrieve exams from the jukebox
#### 7. saveexam short 2 Permission to save the exam format
#### 8. alterdemog short 2 Permission to alter the patient demographics (Name etc)
#### 9. dictate short 2 Permission to dictate an exam
#### 10. clearflags short 2 Permission to clear operational flags for an exam
#### 11. viewvip short 2 Permission to review VIP (private) exams
#### 12. print short 2 Permission to print exams.

### Archive Component

#### Archive

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<td>unique sequential key</td>
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<tr>
<td>last_tape</td>
<td>short</td>
<td>2</td>
<td>last tape initialized for this set</td>
</tr>
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<td>db_name</td>
<td>char</td>
<td>20</td>
<td>name of the tape set</td>
</tr>
<tr>
<td>host_key</td>
<td>int</td>
<td>4</td>
<td>not used anymore</td>
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<tr>
<td>auto_remove</td>
<td>char</td>
<td>1</td>
<td>auto-remove option [Y,N]</td>
</tr>
<tr>
<td>archiv_typ</td>
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<td>Type of archive (primary,secondary)</td>
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#### Tape

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<td>arc_key</td>
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<td>4</td>
<td>relational link to archive table</td>
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<tr>
<td>arc_date</td>
<td>date</td>
<td>4</td>
<td>date tape was initialized</td>
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<td>short</td>
<td>2</td>
<td>tape number</td>
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<td>version</td>
<td>short</td>
<td>2</td>
<td>version of the tape information</td>
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<td>last available position on the tape</td>
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<td>block size used on this tape</td>
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<td>mbytes</td>
<td>short</td>
<td>2</td>
<td>capacity of tape in Mbytes</td>
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<tr>
<td>offsite</td>
<td>short</td>
<td>2</td>
<td>Is the tape onsite or unretrievable?</td>
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#### ArcExam

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<td>relational link to the tape table</td>
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<td>position on tape (tape file=position*2)</td>
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<td>char</td>
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<td>patient ID number</td>
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<td>char</td>
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<td>patient gender</td>
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<td>disk space required for this exam</td>
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<td>exam_no</td>
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<td>3</td>
<td>exam or study number</td>
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<td>int</td>
<td>4</td>
<td>relational link to exam_desc</td>
</tr>
<tr>
<td>exam_date</td>
<td>date</td>
<td>4</td>
<td>date of exam</td>
</tr>
<tr>
<td>modality</td>
<td>short</td>
<td>2</td>
<td>image modality (MR, CT, US, NM)</td>
</tr>
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<td>n_series</td>
<td>short</td>
<td>2</td>
<td>number of series for this exam</td>
</tr>
<tr>
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<td>short</td>
<td>2</td>
<td>number of images total in all series</td>
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<td>4</td>
<td>relational link to the hospital table</td>
</tr>
<tr>
<td>review_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user who reviewed</td>
</tr>
<tr>
<td>dictate_uk</td>
<td>short</td>
<td>2</td>
<td>relational link to user who dictated</td>
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<tr>
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<td>4</td>
<td>relational link to referring</td>
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#### Comments

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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>com_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key</td>
</tr>
<tr>
<td>aexm_key</td>
<td>int</td>
<td>4</td>
<td>relational link to arcexam table</td>
</tr>
<tr>
<td>comments</td>
<td>char</td>
<td>128</td>
<td>comments</td>
</tr>
<tr>
<td>key_words</td>
<td>char</td>
<td>32</td>
<td>key words</td>
</tr>
</tbody>
</table>
Appendix H. Database Architecture

System Component

Host
1. host_key serial 4 unique sequential key
2. hostname char 32 hostname of computer
3. type short 2 type of system (scanner or computer)
4. alias char 34 Alias used in menus for host
5. active short 2 Is the host active [1=yes,0=no]
6. dflt_prt int 4 Default printer for this host.

Users
1. user_key serial 4 unique sequential key
2. username char 8 username
3. alias char 28 Alias used in menus for the individual

ImageDir
1. dir_key serial 4 unique sequential key
2. host_key int 4 relational link to host table
3. dirname char 32 pathname of directory (/host/img)
4. alias char 24 Alias for image directory

Hospital
1. hosp_key serial 4 unique sequential key
2. name char 32 name of hospital

Exm_Desc
1. key serial 4 unique sequential key
2. descr char 28 exam description

Ser_Desc
1. key serial 4 unique sequential key
2. descr char 28 series description

Referring
1. refer_key serial 4 unique sequential key
2. name char 28 referring physician name

Tape Drive
1. drive_key serial 4 unique sequential key
2. host_key int 4 relational link to host table
3. device char 24 device (/dev/nrcht0)
4. blocksize short 2 block size (20)
5. alias char 28 alias for tape drive
6. mbytes short 2 capacity of drive (3000)
7. time int 4 accumulated time in use in sec
8. cleantime int 4 time till cleaning required in sec
9. status short 2 Status of the device (0/1 = ready/busy)
10. type short 2 Type of device (1/2/3 = tape/jazz/mo)
11. devicedir char 32 Mount point for device if MO or CDROM

Printers
1. prt_key serial 4 unique sequential key
2. prt_name char 16 printer name
3. prt_alias char 28 alias for printer
4. type int 4 Type of printer
   1=canon
   2=cemax
   3=SeeMor B/W
   4=SeeMor Color
   5=Internet B/W
   6=Internet Color
   7=SeeMor Color w/Thumbnail
5. host_key int 4 Host printer is attached to if remote printer
Appendix H. Database Architecture

6. **print_dir** char 128 Directory to deposit print page (/img/print default)
7. **width** short 2 Default width of print page in 100\(^{th}\)s of an inch
8. **height** short 2 Default height of print page in 100\(^{th}\)s of an inch
9. **resolution** short 2 Default resolution in dots per inch
10. **print_cmd** char 128 Command to be execute instead of the lp command
11. **jpeg_qual** short 2 Default JPEG quality if compressed printpage (20-90)
12. **pt_info** short 2 Print patient info (0=No, 1=Yes) Allows teaching files to

**FTPbook**
1. **ftp_key** serial 4 unique sequential key
2. **username** char 8 Username for ftp account
3. **passwd** char 16 Password for ftp account (encrypted)
4. **ipaddr** char 16 IP Address of ftp account (or hostname if in /etc/hosts)
5. **dir** char 64 Directory to deposit images on remote ftp system
6. **descr** char 64 Description of ftp recipient

**Phonebook**
1. **phone_key** serial 4 unique sequential key
2. **name** char 32 Name of recipient
3. **areacode** char 16 Phone number area code
4. **modennum** char 16 Phone number of modem
5. **phonenumber** char 16 Phone number of voice
6. **modemspeed** int 4 Speed of modem (eg: 38400) in bits/second
7. **modem_key** int 4 Modem to use when sending to this recipient
8. **next_phone** int 4 Next modem to try if this one busy
9. **max_retry** short 2 Maximum number of redial attempts if busy
10. **call_first** short 2 If not a dedicated modem line, call first = 1
11. **descr** char 64 Description of the Modem Recipient

**Jukebox**
1. **juke_key** serial 4 unique sequential key for each jukebox
2. **host_key** int 4 Host key of workstation jukebox is attached to
3. **status** short 2 Status (0/1/2/3 = READY/BUSY/STOPREQ/UNLOADED)
4. **device** char 24 Device name (/dev/ch0)
5. **manufact** char 24 Manufacturer name (Qualstar/Spectrologic/ADIC)
6. **alias** char 32 Alias name to be used in the menus
7. **archiv_typ** short 2 Type (1/2/3 = Initial/Active/Combined)

**Jukedrive**
1. **jdrv_key** serial 4 unique sequential key for each jukebox drive
2. **juke_key** int 4 Jukebox attached to
3. **drive_key** int 4 Tape drive information
4. **status** short 2 Status (0/1 = Ready/Busy)
5. **slot_key** int 4 Slot key if tape inserted in drive
6. **drive_num** short 2 Drive number (0-4)

**Jukeslot**
1. **slot_key** serial 4 unique sequential key for each Jukebox slot
2. **juke_key** int 4 Jukebox the slot is in
3. **position** short 2 Position of the slot (1-144)
4. **type** short 2 Type of tape in slot (0/1/2/3/4 = empty/RInew/RIn/clean/other)
5. **tape_key** int 4 If type = RI, this is the tape_key for the tape
6. **arc_key** int 4 The arc_key of the tape (If type = RInew or RI)
7. **tape_no** int 4 The tape number of the tape (If type = RInew or RI)
8. **in_jdrv** int 4 Which jukebox drive is the tape in (if not in slot)

**Juketapeset**
1. **key** serial 4 unique sequential key of Supported tapesets on Jukedrives
2. **arc_key** int 4 Link to archive table
3. **jdrv_key** int 4 Link to jukedrive table
### Jukequeue

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key</td>
</tr>
<tr>
<td>juke_key</td>
<td>int</td>
<td>4</td>
<td>Link to jukebox</td>
</tr>
<tr>
<td>type</td>
<td>short</td>
<td>2</td>
<td>Type (1/2/3 = Retrieve/Archive/Clean)</td>
</tr>
<tr>
<td>priority</td>
<td>short</td>
<td>2</td>
<td>Priority of queue item (0-9)</td>
</tr>
<tr>
<td>examkey</td>
<td>int</td>
<td>4</td>
<td>Examkey of exam (or exam_key if retrieve function)</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status of queue item (0/1/2 = Active/Ready/Error)</td>
</tr>
<tr>
<td>dir_key</td>
<td>int</td>
<td>4</td>
<td>Directory the exam is on (or directory to retrieve to)</td>
</tr>
<tr>
<td>arc_key</td>
<td>int</td>
<td>4</td>
<td>Archive to use for archiving and retrieving</td>
</tr>
<tr>
<td>auto_remove</td>
<td>short</td>
<td>2</td>
<td>Remove exam after archiving (1=Yes)</td>
</tr>
<tr>
<td>retrv_cmd</td>
<td>char</td>
<td>256</td>
<td>Command to execute after archiving or restoring an exam</td>
</tr>
<tr>
<td>ins_time</td>
<td>datetime</td>
<td>8</td>
<td>Time item was inserted into the queue (for statistics calcs)</td>
</tr>
</tbody>
</table>

### Modem

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mdm_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key</td>
</tr>
<tr>
<td>portspeed</td>
<td>int</td>
<td>4</td>
<td>Speed of the computer port to set (&gt; modemspeed)</td>
</tr>
<tr>
<td>modemspeed</td>
<td>int</td>
<td>4</td>
<td>Modem speed in bits per second (eg: 28800)</td>
</tr>
<tr>
<td>host_key</td>
<td>int</td>
<td>4</td>
<td>Host key of workstation the modem is on</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status (0/1/2..15 = Ready/Busy/Error … out of service)</td>
</tr>
<tr>
<td>alias</td>
<td>char</td>
<td>32</td>
<td>Name of modem to be used in menus</td>
</tr>
<tr>
<td>device</td>
<td>char</td>
<td>16</td>
<td>Device name (eg: /dev/cua/a)</td>
</tr>
<tr>
<td>area_code</td>
<td>char</td>
<td>16</td>
<td>Area code of modem phone number</td>
</tr>
<tr>
<td>phonenum</td>
<td>char</td>
<td>16</td>
<td>Modem phone number</td>
</tr>
<tr>
<td>dir</td>
<td>char</td>
<td>64</td>
<td>Directory to store temporary images (/img/ftp)</td>
</tr>
<tr>
<td>prefix</td>
<td>char</td>
<td>16</td>
<td>Prefix if required to dial out (“9,” if necessary)</td>
</tr>
<tr>
<td>longdist</td>
<td>char</td>
<td>16</td>
<td>Prefix to dial if long distance (1)</td>
</tr>
<tr>
<td>next_mdm</td>
<td>int</td>
<td>4</td>
<td>Next modem to use if this one is busy</td>
</tr>
</tbody>
</table>

### Modemqueue

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key for each queue item</td>
</tr>
<tr>
<td>mdm_key</td>
<td>int</td>
<td>4</td>
<td>Modem to use for this transmission</td>
</tr>
<tr>
<td>priority</td>
<td>short</td>
<td>2</td>
<td>Priority to handle this item (0-9)</td>
</tr>
<tr>
<td>status</td>
<td>short</td>
<td>2</td>
<td>Status of this item (0/1/2 = Active/Ready/Error)</td>
</tr>
<tr>
<td>send_dir</td>
<td>char</td>
<td>64</td>
<td>Directory to use for temporary storage during sending</td>
</tr>
<tr>
<td>phone_key</td>
<td>int</td>
<td>4</td>
<td>Phone directory to use for sending this data</td>
</tr>
<tr>
<td>user_alias</td>
<td>char</td>
<td>32</td>
<td>Alias for User receiving this data</td>
</tr>
<tr>
<td>entry_time</td>
<td>datetime</td>
<td>8</td>
<td>Time of entry into the queue</td>
</tr>
<tr>
<td>last_time</td>
<td>datetime</td>
<td>8</td>
<td>Last time the transmission was attempted</td>
</tr>
<tr>
<td>delay_time</td>
<td>short</td>
<td>2</td>
<td>Delay time (time between retries)</td>
</tr>
<tr>
<td>max_retry</td>
<td>short</td>
<td>2</td>
<td>Maximum number of retry events</td>
</tr>
<tr>
<td>cur_try</td>
<td>short</td>
<td>2</td>
<td>Number of the current retry.</td>
</tr>
<tr>
<td>remove</td>
<td>short</td>
<td>2</td>
<td>Remove data after transmission (1=Yes)</td>
</tr>
<tr>
<td>descr</td>
<td>char</td>
<td>64</td>
<td>Description of the transmission (errors included)</td>
</tr>
</tbody>
</table>

### Sortarc

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sort_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key for Archive list sorting</td>
</tr>
<tr>
<td>priority</td>
<td>short</td>
<td>2</td>
<td>Priority in menu (order in menu)</td>
</tr>
<tr>
<td>descr</td>
<td>char</td>
<td>16</td>
<td>Description of the sort item (Name, Location..)</td>
</tr>
<tr>
<td>sorttext</td>
<td>char</td>
<td>64</td>
<td>SQL sort text to sort the list by</td>
</tr>
<tr>
<td>user_key</td>
<td>int</td>
<td>4</td>
<td>If applicable to only 1 user, include user_key here</td>
</tr>
</tbody>
</table>

### Sortpat

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sort_key</td>
<td>serial</td>
<td>4</td>
<td>unique sequential key for Patient List sorting</td>
</tr>
<tr>
<td>priority</td>
<td>short</td>
<td>2</td>
<td>Priority in menu (order in menu)</td>
</tr>
<tr>
<td>descr</td>
<td>char</td>
<td>16</td>
<td>Description of the sort item (Name, Location..)</td>
</tr>
<tr>
<td>sorttext</td>
<td>char</td>
<td>64</td>
<td>SQL sort text to sort the list by</td>
</tr>
<tr>
<td>user_key</td>
<td>int</td>
<td>4</td>
<td>If applicable to only 1 user, include user_key here</td>
</tr>
</tbody>
</table>

### Sorting
### ISTdefaults

1. **param** serial 4  unique sequential key for Image List sorting
2. **descr** char 32  Description of default item
3. **value** int 4    Integer value of numeric item
4. **cvalue** char 64 Character value of ascii item

### ISTdefaults

1. **sort_key** serial 4  unique sequential key for Image List sorting
2. **priority** short 2   Priority in menu (order in menu)
3. **descr** char 16  Description of the sort item (Name, Location...)
4. **sorttext** char 64 SQL sort text to sort the list by
5. **user_key** int 4    If applicable to only 1 user, include user_key here
B. File Structure

The file structure within the RI system is considered distributed in architecture, since the images can exist on any of the disk drives on any system within the network. In order to accomplish this the first part of the file structure must be the hostname of the system containing the physical disk. The second part of the directory structure must specify which directory or which disk is to be used. The third part must specify the database (if multiple databases are in use on a particular partition). Then the exam number must be specified. Since multiple scanners are being integrated within the network, the normal exam number is not used, since it is likely that this will not be unique. Therefore the database creates a unique exam_key which is used to specify the exam directory. The series number for each series is specified next since it should be unique. And finally, the images are specified by their image number preceded by "RI."

This structure results in the following file names:

/net/hostname/disk_or_dir_name/database/exam_key/ser_no/RI.img_no

For a system named "enterprise", with a disk partition called "img", and a database called "radiol", image five of series three for exam 4576 would be specified "/net/enterprise/img/radiol/4576/3/RI.5"

If the system contains multiple RI workstations, then the network file sharing system "NFS" must be set up so that each system will see the other system's image directories. For example, if another system called "sunrise" were added to the system, in order for sunrise to see its own image directory "/img" and enterprise's directory "/img" the following directories must be visible from both sunrise and enterprise (automount links at /net):

/net/sunrise/img/...
/net/enterprise/img/...

In this manner, any available disk space can be configured to act as image directories. The ImageDir database table will have to be updated to inform the RI system of any changes in the image directory structure. The installation process configures the Host and ImageDir database tables.
Appendix I.

ACR    Acronym for the American College of Radiology - A society of medical professionals.

ANSI   Acronym for the American National Standards Institute. ANSI sets standards for the computer industry.

application A software program which performs specific functions such as image import/export or image display.

ASCII Acronym for the American Standards Committee for Information Interchange. Often used to describe an ordered set of printable and non-printable characters used in computers.

axial The orientation of an image plane that is perpendicular to the patient's head to foot axis. The edges of this plane consist of the anterior, posterior, right and left sides of the patient.

byte A unit of storage approximately corresponding to 1 character. A kilobyte is 1024 bytes. A megabyte is $10^6$ bytes. A gigabyte is $10^9$ bytes.

colormap A term referring to the translation of inherent image colors or greyscales to those colors which may be displayed on the graphics monitor. If a workstation supports 8 bit color display, then it can show 256 simultaneously colors or greyscales. However, since images usually have 12 bits of information ($2^{12}=4096$ shades), a colormap must be used to determine which of the 4096 shades are displayed in the 256 positions.

coronal The orientation of an image plane that is perpendicular to the patient's anterior to posterior axis. The edges of this plane consist of the superior, inferior, right and left sides of the patient.

DAT    Acronym for Digital Archive Tape - A standard by which digital information can be stored on 4mm DAT tape cartridges. This digital storage media is not only high capacity (2-5GBytes per tape), but it is also very small consuming very little storage space.

database A collection of information (contained in tables) that is useful to a particular organization or used for a specific purpose.

DICOM A communication standard for medical images and other information as established by ACR-NEMA and the Mallinckrodt University. The original components of this standard only involved image transfer and header specifications, however the scope of this standard now encompasses network protocols, printing services, archiving functions and database support functions to name a few.
<table>
<thead>
<tr>
<th>Glossary Item</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethernet</td>
<td>Technology allowing the transfer of digital information across various types of media: copper wire (thick, thin or 10BaseT), microwave, or satellite. This standard, prescribes the protocols for digital communication between various types of computer systems. It also allows for the high speed transmission of patient image information.</td>
</tr>
<tr>
<td>Exabyte</td>
<td>A trademark for the technology which allows the storage of digital information on 8mm data cartridges. This technology allows high capacity digital archiving with storage space for upwards of 10GBytes of information per tape.</td>
</tr>
<tr>
<td>GByte</td>
<td>Giga-Byte - One Thousand Megabytes.</td>
</tr>
<tr>
<td>hostname</td>
<td>The name given to a networked workstation. Each workstation within a local area network must be given a hostname which is unique among all the workstations on the network. This host is also given a unique internet address. This is analogous to your home address in that information (mail) sent to this address will only go to ONE workstation (or house).</td>
</tr>
<tr>
<td>icon</td>
<td>A graphical representation or picture of an application or of an interface function (button for example). Each Rational Imaging application has an icon associated with it which depicts its major function. When the application is closed down without quitting, it will be displayed as its icon at the bottom of the workspace. The program is still operating and performing functions, however it does not consume screen space when in its iconic form.</td>
</tr>
<tr>
<td>iconify</td>
<td>The operation of closing down an application window to its icon form.</td>
</tr>
<tr>
<td>interpolation</td>
<td>The process of generating high quality magnified images from low resolution source images. Rather than duplicate the inherent pixels which produces a square box effect, interpolation calculates an average image intensity for each magnified pixel based upon a weighted average among all of its neighboring pixels.</td>
</tr>
<tr>
<td>IST</td>
<td>Intuitive Software Technology - The creator of the set of Rational Imaging software applications.</td>
</tr>
<tr>
<td>load template</td>
<td>A template used by the Rational Imaging system which defines default characteristics of a displayed exam. This template is defined by the user and will determine the default image locations, window/level characteristics and magnification factors of each image within the display. It will also create duplicate windows and maintain efficient and consistent control of the initial image display. This element of the review display program was designed to minimize the effort required to prepare a diagnostic exam for review and printing.</td>
</tr>
<tr>
<td>login</td>
<td>Each user can have his/her own account on UNIX based systems. In order use the system, however, you must log in by entering your username at the login: prompt. If your account is password protected, then you will be prompted to enter your password. All the applications that you run will be linked to your username. You will also have a partition of the disk called your HOME directory where you can store your own data files.</td>
</tr>
<tr>
<td>logout</td>
<td>After completing your session on the workstation, it is recommended to logout by typing logout, exit, or selecting the exit option from the workspace menu.</td>
</tr>
</tbody>
</table>
When you are using the Rational Imaging system, be careful when exiting the Open Windows system because you will kill any operating applications such as ristore or riport. Therefore, it is recommended to logout using the logout button on the rilogin application.

**meta key**
A key on the lower left portion of the keyboard resembling a diamond (♦).

**multi-tasking**
The ability of SUN's SPARC processor to perform multiple functions at the same time. This is actually a function of the UNIX operating system. Multi-tasking allows you to display two exams side by side, or review a case at the same time you are importing and archiving exams. This minimizes the amount of time that you will be waiting for the computer.

**MRI**
Magnetic Resonance Imaging or MR - A highly sophisticated form of diagnostic scanners which use high strength magnets to obtain images inside the human body.

**NEMA**
National Electronics Manufacturing Association

**NFS**
Network File Sharing - The ability to attach disks to your system which may exist on another workstation on the network. Once these disks are attached (mounted), your applications will be able to access files on the disks as if the remote disks were physically attached to your system. The network becomes transparent except for a slight performance degradation due to the network transport involved.

**Open Windows**
The graphical user interface (GUI) provided by SUN for their UNIX based workstations. Open Windows supports the X protocol and comes with the DeskSet Utilities.

**PACS**
Picture Archiving and Communication System - A system which handles the communication of digital images through a network of image display workstations. Diagnostic review, quantitative imaging, teleradiography, along with long term storage of the images are but a few of the functions provided by PACS.

**PFI**
Paper Film Imager - The device developed by Canon which produces high quality diagnostic hardcopy.

**pixel**
A single unit of intensity information within a given image which usually consists of 8 bits or 256 shades of grey. An image is made up of many pixels. If the image dimensions are 256 by 256, then the image will contain 256*256=65,536 pixels.

**popup**
A window within the Open Windows environment which can contain images, menus, patient lists, or other parts of an application's interface.

**print template**
A template used by the Rational Imaging system which defines default characteristics of a print page such as image size, location of images, number of images, textual annotation and exam specific vocabulary.

**printtool**
A software application provided by SUN in their DeskSet Utilities. This program allows you to query the printer, start and stop print jobs, and otherwise control the print queue.
RAM | Random Access Memory - The physical memory on an individual workstation which allows you to load images and interact with them very rapidly. Since each patient exam can consist of upwards of 20MBytes of information, it is important to have sufficient RAM to allow efficient display of these images. RAM is also utilized by UNIX, your programs, the print queue and various database applications.

RAS | Right Anterior Superior - The coordinate system used in medical imaging. R stands for the Right/Left orientation of the image. A stands for the Anterior/Posterior orientation of the image. S stands for the Superior/Inferior orientation of the image. Thus, since each image's orientation and location may be perfectly defined in 3 dimensional space using the RAS coordinate system.

Rational Imaging | A collection of software applications developed to provide the functionality required for filmless imaging. Image transfer, review, archiving and printing are the major components of this system. Additional applications augment this environment by offering enhanced display features (MR angiography) or quantitative information (cardiac analysis).

riconnect | Rational Imaging software which connects with remote networked scanners and allows image transfers to occur. This application runs in the background of the UNIX operating system as a daemon.

rilogin | Rational Imaging software which allows you to login, logout, and run various programs within the Rational Imaging system. This application is considered the "program launcher".

rimove | Rational Imaging software which allows you to remove patient images, series and exams from the Rational Imaging PACS system. Use this application with great caution. It is recommended to use ristore to archive and auto-remove the exam since this will ensure that you have archived the most recent changes to the exam layout.

riport | Rational Imaging software which allows you to import and export images to various remote scanners. Some scanners require the use of riconnect to aide in this transfer.

RIS | Radiology Information System - A system by which the staff can schedule, perform exams, produce reports and otherwise handle the workflow of a radiology department.

RISC | Reduced Instruction Set Chip - A powerful evolution in computer technology which improves the performance of computer graphics workstations through simplified CPU instruction sets.

ristore | Rational Imaging software which performs the archival and retrieval of patient exams. This application provides the functionality required for long term storage of diagnostic exams.

riview | Rational Imaging software which efficiently displays, manipulates, and prints diagnostic images.

ROI | Region of Interest - This is a region defined by the operator which contains a defined set of pixels. It can be rectangular, circular or of irregular shape. The average intensity of an ROI is the average intensity of the set of pixels.
sagittal The orientation of an image plane that is perpendicular to the patient's right to left axis. The edges of this plane consist of the superior, inferior, anterior and posterior sides of the patient.

SCSI Small Computer Systems Interface - A type of communication standard which defines how computers will interface with various peripheral devices such as disk or tape drives.

SPARC A super-scalar central processing unit (CPU) produced by SUN for their high performance workstations.

SQL Acronym for Standard Query Language. A database query language developed by IBM and standardized by ANSI. The Rational Imaging database is based on an extended implementation of ANSI standard SQL.

Suboptimal Annotation shown when the image is insufficiently displayed. If any image information is hidden, such as when the image has been clipped, or if the image display size is less than the inherent resolution of the image, then this annotation will appear on the footer of the image popup.

SUN Manufacturer of high quality, high performance computer workstations.

TCP/IP Transmission Control Protocol/Internet Protocol. A popular ethernet protocol used by UNIX to communicate over network lines.

Teleradiography The ability to transmit images over standard phone lines to physician's homes or remote facilities. This type of image communication dramatically improves the ability to obtain second opinions or provide on-call radiology support.

textedit A software application provided by SUN in their DeskSet Utilities. This program allows you to edit various ASCII or text based files on the system. All of the Rational Imaging templates are ASCII, and thus can be modified by using textedit.

UNIX The operating system for Sun SparcStations. UNIX provides a very powerful environment for computer imaging. The inherent multi-tasking capabilities allow you to run multiple applications simultaneously. UNIX's integrated network support allows you to communicate with remote workstations and support PACS.

user An individual user of the UNIX operating system and the Rational Imaging system. A UNIX user must have an account and a HOME directory provided by the system's administrator. A Rational Imaging user must additionally have an account created in the database tables giving him/her sufficient access to the patient exams. The system's administrator is capable of adding/deleting users at any time.

username The 8 character name given to an individual user. This name must be unique within the system.

Work Space The display screen used to display various applications and UNIX programs. This graphical environment consists of a colored background which is user definable, and a default workspace menu which will appear each time the right mouse button (menu button) is pressed while the cursor is over a blank portion of the workspace.
WYSIWYG  What You See Is What You Get - A term referring to the correlation between the information displayed on monitors and the hardcopy produced by the print command. If WYSIWYG technology is applied to the computer display characteristics, then the printed hardcopy should duplicate what the display is showing (albeit the hardcopy may have slightly less or greater inherent resolution than the monitor).
Appendix J.

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