

# DSM in Radiological Image Management

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Digital Equipment Corporation's version of MUMPS, DSM V2.0, is used as a major component in Gould's implementation of a Picture Archiving and Communication System (PACS). This particular PACS is the product of the Imaging and Graphics Division of Gould, Inc. and is an operational digital radiographic image management system using touch sensitive screens. This paper briefly describes Gould's Multimodality Acquisition and Review System (GS1000) and emphasizes the MUMPS component of the product. The MUMPS component is addressed by discussing the language considerations in the product development, the data entry/edit and image display screens, and the MUMPS database.

## Introduction

The design considerations for Gould's Multimodality Acquisition and Review System were reported at SCAMC, October 1983 [1] and the GS1000 was first shown during the November, 1983 RSNA con-

ference. The System continues to undergo development with additional features added as the hardware and software become available.

The flexibility of the GS1000 provides for several logical configurations. In one configuration, shown in Figure 1, the GS1000 is implemented on a DEC VAX 751 as host running under VMS. It has a Gould IP-8500 as the image processor, and the Gould Real Time Digital Disk as the image mass storage device. DEC VT101s with advanced video, Carroll touch sensitive screens, bar code reader, and trackballs or joysticks function as the user I/O devices with the multimodal images being displayed on various models of 1024 monochrome or color monitors.

The images may be multimodal; that is, nearly any picture which can be digitized or transmitted via RS170 protocol can be supported, (e.g., Computerized Tomography, Digital Subtraction Angiography, Magnetic Resonance Imaging, digitized Radiographic, and Ultrasound). The GS1000 displays images that are 1024 x 1024 bytes by 8 to 12 bits. Smaller images are supported by tiling, e.g., four 512 x 512 images can be displayed on a 1024 monitor. Larger images such as 2048s are also supported and may be viewed by roaming around the image and viewing any 1024 x 1024 byte portion. With the Real Time Digital Disk a 512 x 512 x 8 image can be taken from the Winchester disk and displayed in 1/30th of a second.

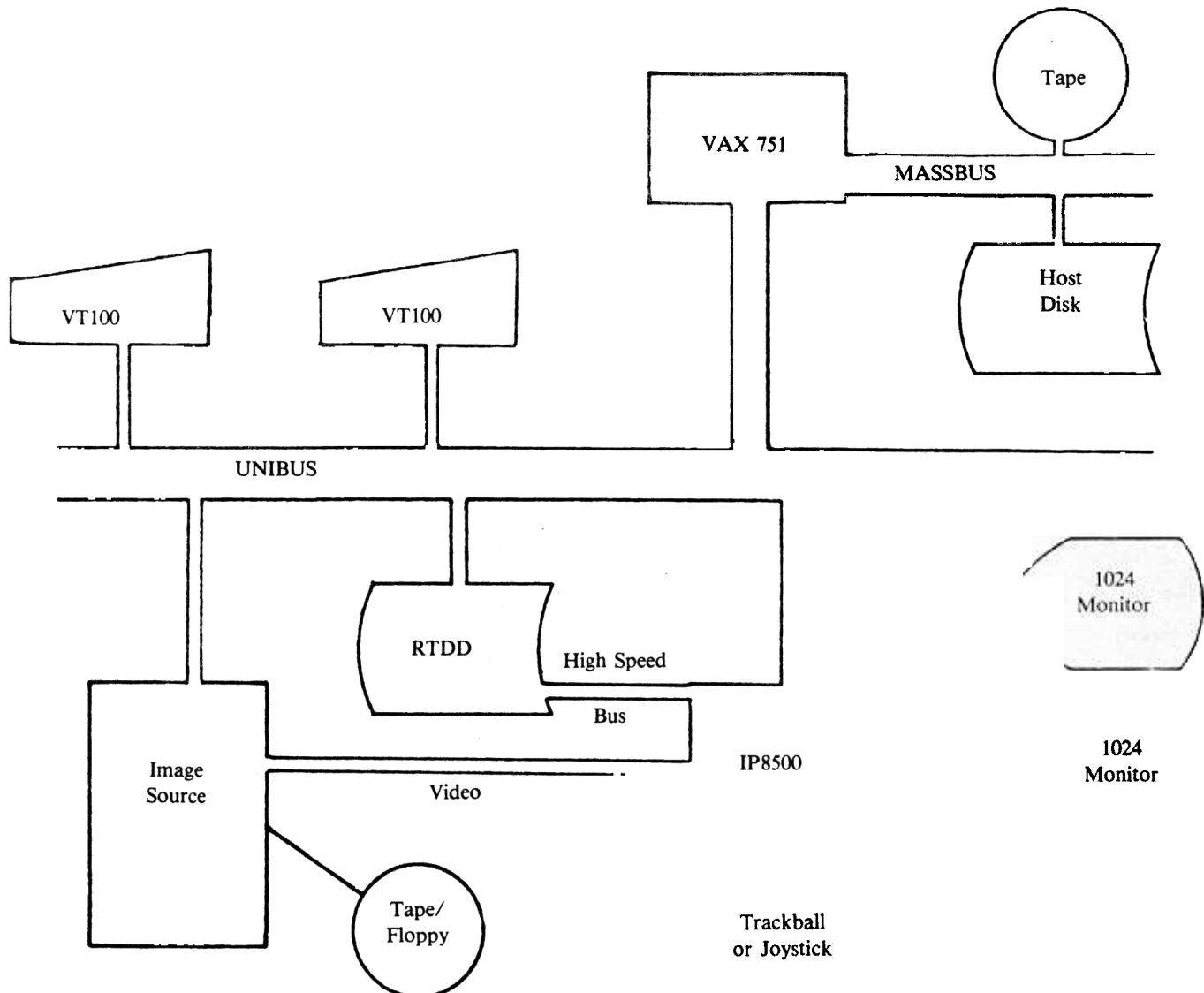


Figure 1. Simplified Configuration of a Multimodality Acquisition and Review System (GS1000).

Routines written in DEC Standard MUMPS form the software foundation of the GS1000. These routines include \$ZCalls to externals such as FORTRAN subroutines and MACROs. The externals are used for I/O, drivers, actual image acquisition and filing, and interfacing to and controlling the IP8500 and Real Time Disk. Essentially, the routines written in DSM function in image management and user interfacing tasks while the FORTRAN and MACRO routines accomplish the actual image display and enhancement and hardware tasks.

The standard software functions supported by the GS1000 include:

1. logon with security,
2. system bulletin board,
3. GS1000 system utilities,
4. patient identification by name (includes soundex), patient ID, and/or hospital exam number,
5. patient admittance information including demographics and third party billing,
6. review of images by modality and radiologist,
7. display and creation of alternators (alternators in this context are a series of monitors that display a related set of images),
8. display of images in a subsampled mode as well as the normal 1024 x 1024 mode, and
9. manipulation of images by zooming, scrolling, brightness transfer function, windowing, movie looping, filtering, and inverse video.

In summary, the GS1000 software functions in an image management capacity by enabling the user to describe and manipulate a patient data base, schedule image acquisition, acquire and store images, create alternators, display images by patient and/or alternator, enhance and examine those images, and file and/or delete images as required.

### Language Considerations

A multitude of factors were considered when deciding upon the language(s) in which to implement the Multimodality Acquisition and Review System. The FORTRAN and MACRO routines were necessary for greater hardware control than available through DSM. Additionally, many of the routines for the IP8500 had previously been written in FORTRAN and MACRO. Thus the major decision was determining in which language to implement the user interface routines. The rationale for using DSM included the following considerations:

1. the ability to generate usable code in a timely fashion,
2. ease in programming formatted screens,
3. the adaption of the touch sensitive screen capabilities,
4. the flexible file structure inherent to MUMPS,
5. the acceptance of MUMPS by the Medical Community,
6. the relative ease and quickness that MUMPS can be learned by new personnel, and
7. DEC's support of MUMPS via DSM.

Few decisions in life are without their disadvantages, which in the use of DSM include:

1. the need to use FORTRAN and MACRO to accomplish the more sophisticated I/O,
2. the lack of processing speed in DSM V2.0 vs. FORTRAN,
3. lack of parameter passing (V3.0 may have solved some of the problems with performance and function),
4. the paucity of MUMPS programmers (in-house training needed),
5. the lack of inherent structure to MUMPS,
6. the tendency toward writing abstruse code which is not self-documenting, and
7. the recurring cost of DSM in VAX implementations.

## Screens

### Description

The main user interface to the GS1000 is via MUMPS through the VT101s (using the keyboard and/or the touch sensitive screens). The macro functional flow through the initial GS1000 screens is depicted in Figure 2. From Figure 2 it can be seen that the entry/edit and display of data and images are tied to specific screens. The screens that are/will be initially supported include:

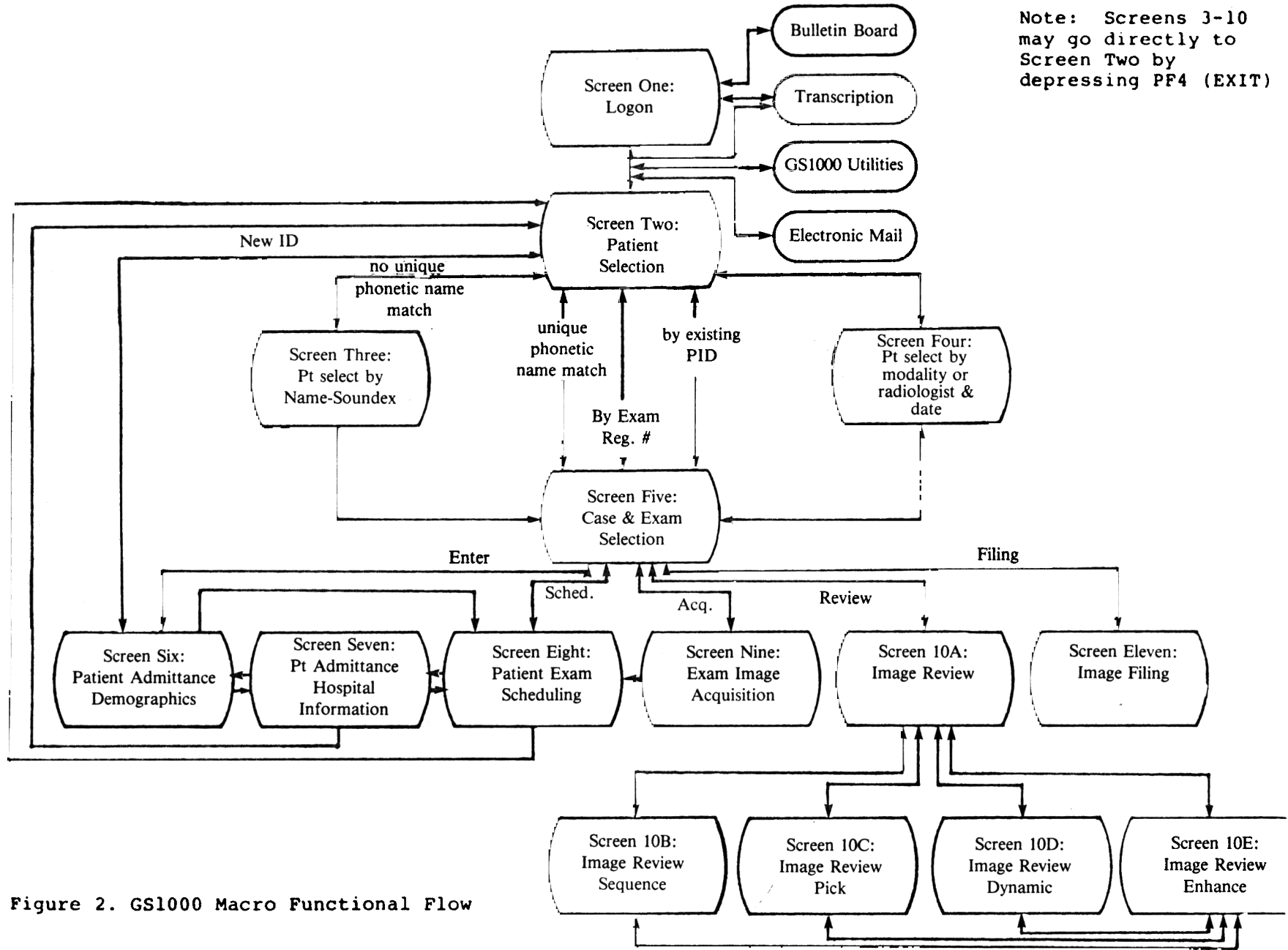
1. logon and bulletin board
2. main menu
3. patient selection by name (soundex)
4. schedule for radiologist or modality
5. case and exam selection
6. patient admittance (demographic)
7. patient admittance (insurance)
8. exam scheduling
9. image acquisition
10. image review
11. image filing
12. image order head
13. image deletion
14. utilities main menu

Examples of the case and exam selection, patient admittance, and image review screens are depicted in Figures 3, 4, and 5, respectively.

### Usage

Except for the entry of the patient's data in screens six and seven (patient admittance) and in a few other screens which ask for chart number, patient name, etc. all the physician interaction via the VDT is through the touch sensitive screen. The following example of the steps necessary for a physician to review a set of images (for a specific patient) is presented so the reader can conceptualize the processes involved (also see Figures 2, 3, 4, and 5.)

1. Log on to GS1000 (screen one) by typing in user name and ID.
2. Select patient by any ONE of the following methods:
  - a. By name
    - i. type in patient name and if a unique phonetic match is found in the data base the process flow goes to screen five,
    - ii. if no unique match, the flow goes to screen three where a listing of the available patients is displayed and the physician touches the line which displays the appropriate patient and then touches the 'PROCEED' box at the bottom of the screen to get to screen five.
  - b. By ID
    - i. the patient ID can be directly entered via a bar code reader (bar code previously affixed to chart and the chart is available) then flow proceeds to screen five,
    - ii. the ID is entered manually via keyboard and the 'PROCEED' box is touched; the flow proceeds to screen five.
  - c. By modality
    - i. the modality code (CT, US, NM, etc) and date the pictures were taken are entered via the keyboard,  
—screen four is displayed and the line that shows the appropriate set of images for the patient is touched,  
—then the 'PROCEED' box is touched and flow proceeds to screen five.
  - d. By radiologist—similar to modality except the appropriate physician's name is entered via the keyboard.
  - e. By exam number (unique Radiology Department number which differs from the case and exam number)



Note: Screens 3-10 may go directly to Screen Two by depressing PF4 (EXIT)

Figure 2. GS1000 Macro Functional Flow

Figure 3. Screen Five—Case and Exam Selection.

**CASE AND EXAM SELECTION** **BACKUP**

LAST NAME PATIENT FIRST NAME JOE INITIAL Q  
 PATIENT ID 123456789 AGE 24 SEX M

Case	Exam	Modal	Date		STS	#/mg	Size	Impression
12	101	XR001	mm-dd-yy	Radiologist Name	V	4	1024x8	texttexttext
	100	XR002	mm-dd-yy	Radiologist Name	A	24	512x8	impression
11	3	US001	mm-dd-yy	Radiologist Name	P	46	64x10	texttexttext
	2	US001	mm-dd-yy	Radiologist Name	R	8	64x10	impression
	1	NM001	mm-dd-yy	Radiologist Name	A	4	512x12	impression

Select a Function or a CASE or EXAM Entry from the screen

Figure 4. Screen Six—Patient Admittance (demographic)

**PATIENT ADMITTANCE** **BACKUP**

**PATIENT INFORMATION SECTION**

LAST NAME \_\_\_\_\_ FIRST NAME \_\_\_\_\_ INITIAL \_\_\_\_\_

PATIENT ID \_\_\_\_\_ SOC SEC NO. \_\_\_\_\_ BIRTH DATE \_\_\_\_\_ AGE \_\_\_\_\_

SEX \_\_\_\_\_ RACE \_\_\_\_\_ MARITAL STAT \_\_\_\_\_ PT STATUS \_\_\_\_\_

STREET ADDR \_\_\_\_\_

STATE \_\_\_\_\_ ZIP CODE \_\_\_\_\_ TELEPHONE NO. ( ) \_\_\_\_\_

EMPLOYER NO. \_\_\_\_\_ INS GROUP NO. \_\_\_\_\_

Select a Function

Figure 5 Screen Ten A—Image Review

**CLEAR** **REVIEW** **BACKUP**

LAST NAME \_\_\_\_\_ FIRST \_\_\_\_\_ INTL \_\_\_\_\_

PATIENT ID \_\_\_\_\_ AGE \_\_\_\_\_ SEX \_\_\_\_\_

CT002 mm/dd/yy 24 V

Lateral	1	A	MONITOR	<div style="border: 1px dashed black; width: 30px; height: 30px; margin: 5px auto; text-align: center; line-height: 30px;">1</div>	<div style="border: 1px dashed black; width: 300px; height: 150px; margin: 5px auto;"> <table border="1" style="width: 100%; height: 100%; border-collapse: collapse;"> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </table> </div>																
Lateral	2	A																			
Lateral	3	V																			
Lateral	4	A																			

NM001 mm/dd/yy 104 V

Lateral	1	V	MONITOR	<div style="border: 1px dashed black; width: 30px; height: 30px; margin: 5px auto; text-align: center; line-height: 30px;">2</div>	<div style="border: 1px dashed black; width: 300px; height: 150px; margin: 5px auto;"> <table border="1" style="width: 100%; height: 100%; border-collapse: collapse;"> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </table> </div>																
Lateral	4	V																			
Lateral	6	A																			
Lateral	9		MONITOR	<div style="border: 1px dashed black; width: 30px; height: 30px; margin: 5px auto; text-align: center; line-height: 30px;">3</div>																	
Lateral	14	A																			
Lateral	18	A																			

Select a Function

- i. The Radiology Department exam number is entered manually via the keyboard and the 'PROCEED' box is touched and flow proceeds to screen five.
3. If there is only one case/exam (one set of images) for the patient then the image review screen is the default; otherwise the user touches the appropriate line (case/exam) and the 'REVIEW' box; the flow proceeds to screen ten.
4. The methods for reviewing images from screen ten include:
  - a. pick mode—select a particular image by touching the line containing the image to be displayed, touch the box that corresponds to the monitor where the image is to be displayed, and the placement of the image on the monitor if the image is smaller than 1024 x 1024,
  - b. sequence mode—the images listed are displayed in sequence beginning on the monitor specified,
  - c. dynamic mode—movie loop mode, where by specifying the monitor and position, a set of images is displayed sequentially,
  - d. enhance mode—using this mode the images are displayed as in 4a but the trackball or joystick is used by touching the appropriate boxes at the bottom of the screen. The images(s) can be zoomed, histogrammed, roamed, etc.
5. To return to screen two at any time, the PF4 key is depressed or the 'BACKUP' box on each of the screens can be touched to backup the process.

From the lengthy example above, it may seem quite involved to display an image. However, an image can be displayed, after logon, with as few as four individual entries (including screen touches). As Radiology departments differ in their methodology and management it is expected that the flexibility of MUMPS will enable customization of the GS1000.

Originally the screens were written to the VDT by loading the specific DSM display routine for that screen. The screen was then output. To decrease the actual and perceived time necessary to display the screens they will be Xecuted from a global. The global consists of write statements containing screen control and verbiage display code. With this schema the screen for the next process will be executed from the screen global prior to the loading of the new routine. To make the development of the screens easier a screen maker has been written in MUMPS which supports all the DEC VT101s graphic functions.

#### Database Description

The GS1000 consists of a central database which contains information for each active patient (termed the Ten Day Patient Database). This central database will support an archival database (the Archive Patient Database) which contains information on all patients ever entered into the system. The Archive Patient Database contains the same database layouts as the Ten Day Database and differs only in those areas where there are pointers to text or images. Since text and images in the Archive Patient Database will not be online, these pointer values contain offline references which can be used to reload the desired text and/or images. The rationale for the separate databases is to minimize the size of the Ten Day Database for efficiency in access speed and storage utilization.

The GS1000 database includes upright files for patient and image data, bulletin board, image directory bit map, and user security information as well as inverted globals for the patient soundex, radiologist's names, image modalities, and radiology exam number. The patient data fields include the patient's name, social security number, date of birth, sex, race, marital status, location, employer number, insurance data, address, phones, attending physician(s), complaint(s), and image data. The image data includes date and time of exam, modality, status,

image size and depth, number of images, exam test, radiologist(s), pointers to the image on the disk, time of image acquisition, descriptor, and source.

In order to efficiently store and access the data collected, a MUMPS database handler was written. The database handler enables continuity in the database as data fields can be changed and added relatively painlessly. To use the handler the programmer specifies the name of the global to be accessed and the type of I/O request to be performed. The types of I/O requests include:

1. read database record using appropriate keys,
2. update database using appropriate keys and build any associated inverted lists,
3. get the next subscript based on current key values, update key and read next record in database,
4. initialize the member elements of a database using the corresponding record passed, and
5. update database using appropriate keys.

The database handler returns the status of the database request as database operation successful, invalid parameter(s) passed or parameter(s) undefined, I/O error accessing the database, or no database entry associated with implicit key(s).

#### Conclusions

After much continued collaboration on the design specifications for the GS1000 it took four programmers the equivalent of less than one-man year to write all the initial MUMPS code. This seems noteworthy as there were some 5,125 lines of code written during that period or approximately 23 multistatement lines of usable code per day for a year. Additionally, there seems to have been fewer problems with the MUMPS code than with the FORTRAN and MACRO code. Granted, the code external to MUMPS was extensive and relatively complex which would tend to counter the previous statement. The bottom line is that the use of MUMPS enabled Gould to implement the initial version of the GS1000 in a timely manner making Gould one of the first companies with an operational PACS.

#### References

1. Gray, M., and Rutherford, H., Efficacy of a Real-Time Digital Lightbox. SCAMC, October 1983.

The author acknowledges the able assistance of Cynthia Carter and Melissa Biggs.

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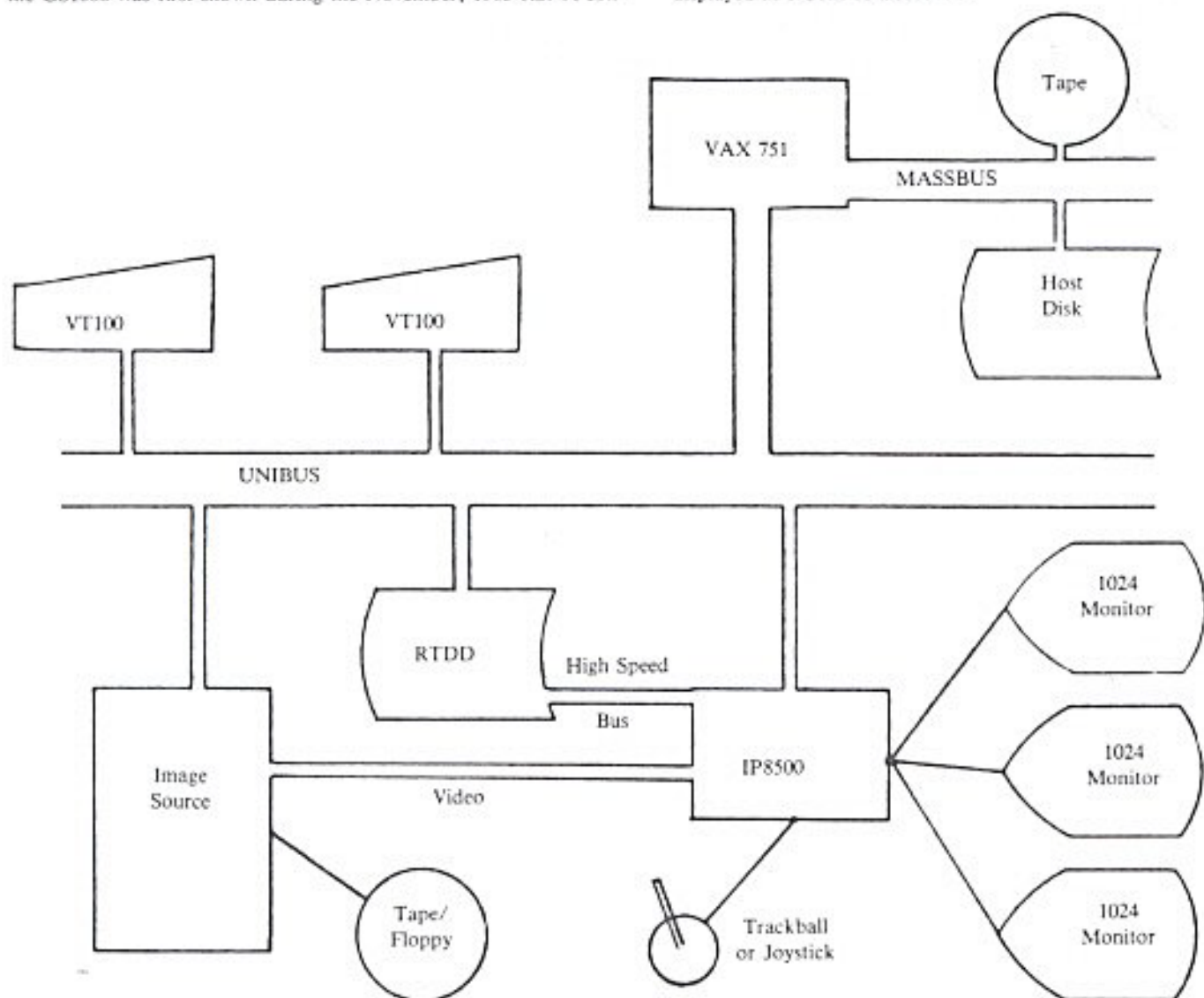


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