Patterns of Utilization of Computer Workstations in a Filmless Environment and Implications for Current and Future Picture Archiving and Communication Systems

Eliot L. Siegel, Zenon Protopapas, Bruce I. Reiner, and Stephen M. Pomerantz

ONE OF THE biggest challenges in the planning, purchase, and implementation of a large-scale picture archiving and communication system (PACS) is the determination of the number, type, and location of imaging workstations for the entire health care facility or health care network. This is particularly critical given the fact that imaging workstations are still relatively expensive, with a high-resolution (2000 pixel), four-monitor workstation ranging in price from $30,000 to $180,000, and even "low end" workstations typically costing several thousand dollars. Once a PACS has been implemented, there is still a continuing need to determine the amount and timing of utilization of the workstations to help optimize the deployment of these expensive components.

In addition to determining the number, type, and location of workstations, it is also critical to anticipate the amount of utilization of the imaging network and to estimate the amount of network "traffic" during the day. This can help determine which architecture would be best for a particular installation. The relative use of the imaging network also can have a major effect on the capacity required for the short-term image server and for the long-term archive and potentially the type of long- and short-term archives required.

A deficiency of current large-scale PACS is the lack of an administrative tool to determine the utilization of imaging workstations on an on-going basis. Such a tool would permit an analysis of the average number of workstations used throughout the day and to determine the periods of peak use. This could be used to estimate the average and peak amount of network traffic, which could result in the ability to optimize the price-to-performance ratio for the network as well as the short- and long-term storage devices. This monitoring tool also would help the system administrators to determine whether there was sufficient use of the PACS at a particular location to justify the deployment of a workstation there. Alternatively, a very high-utilization rate at a particular location might justify the deployment of an additional workstation.

The average and peak rates of workstation utilization throughout a working week for a number of PACS sites could provide objective data that could be used by vendors and customers in the future to determine the size of a PACS network and the amount and type of image storage. This information also could be used to determine the clinical requirements for the number and type of imaging workstations.

PURPOSE

The purpose of the study was to develop a methodology to determine the utilization of imaging workstations and to analyze the relative use of these workstations in a medium-sized academic medical center that operates in a "filmless" environment.

MATERIALS AND METHODS

Workstation utilization data were collected during a 1-week (168-hour) interval using the hospital-wide PACS at the Baltimore VA Medical Center.[1] A computer program was written for the database server, which created a list that contained the date, time, "status," "loginame" (name of person or process using that workstation), "command" (workstation task), and hostname (workstation location). This list was generated and appended to a file every 15 minutes during the 1-week period, and resulted in 672 queries. This created an ASCII file that was imported into a *Microsoft Excel* spreadsheet for subsequent analysis. A manual "spot-check" was performed to determine the validity of the data that were generated by this program. Determination was made about whether the workstation was actually in clinical use or was idle, whether the user was actually the one listed in the database, and whether the workstation had performed a "time-out."

RESULTS

Workstation utilization was found to be variable during the course of the week. The workstations in

From the University of Maryland Medical School and the Baltimore Veterans Affairs Medical Center, Baltimore, MD.

Address reprint requests to Eliot L. Siegel, MD, Radiology and Nuclear Medicine, Baltimore VA Medical Center, 10 North Greene St, Baltimore, MD 21201.

0897-1889/97/1003-1020$0.00/0

the radiology department that were used most heavily were, as expected, those that functioned as interfaces between image acquisition devices and the PACS. The next most heavily used workstations during the day were the diagnostic radiology workstations located throughout the department. The use of these workstations paralleled the work schedules of the radiologists. Workstation utilization throughout the remainder of the medical center also was busiest during the mid portion of the day from 9:00 A.M. until 4:00 P.M. The heaviest utilization occurred in the clinics and the emergency room and to a lesser extent in the intensive care units during morning and afternoon rounds. Also, as expected, a few of the workstations were used very infrequently.

The "spot-check" of actual workstation use as determined by direct observation in comparison with the reported use revealed that the workstation utilization program substantially overestimated the actual amount of workstation activity. This occurred because there was a large amount of variability in the workstation timeout parameters throughout the medical center. In some areas such as the operating room, the workstation timeouts were set to a relatively large number to prevent premature sign-off of the imaging stations. Thus, the operating room workstation appeared to the computer program to be used throughout the day, despite the fact that the use of this workstation was actually quite low.

The workstation utilization database also highlighted a security flaw in the PACS. Numerous instances of a user being signed on simultaneously using more than one workstation were noted. This occurs because of the tendency of users to share their user name and password combinations with their colleagues. The PACS should be modified to not permit a new user to log onto the system with a user name and password combination that is already in use. Additionally, most users do not log off the system when another clinician is waiting to use the workstation and thus permit the next user to obtain images using their name and password combination. This also results in a tendency of the workstation utilization program to overestimate the amount of time each clinician is using the system and underestimate the number of users of each workstation.

DISCUSSION

The ability to monitor PACS workstation use is critical for a number of reasons, and consequently this tool should be requested routinely and included with the purchase of a large-scale PACS.[2] A workstation monitoring database can be analyzed to determine a number of important parameters.[3] These data can be used to determine the overall system architecture; size of the network and storage devices; and number, type, and location of PACS workstations. Other important uses for this information include monitoring of workstation use for security purposes and determination of optimal workstation time-out settings for security and performance purposes. Additionally, these data can be used in the analysis of the types of users and images that are most frequently requested during various parts of the day or week to optimize image retrieval algorithms. This information can help determine which systems are in need of maintenance before notification by the users and to determine optimal times for global or "local" system preventative maintenance.

Although the workstation monitoring "script" that was used to create the database was able to document general workstation patterns of workstation utilization, the methodology had a number of drawbacks that substantially limited its usefulness. The program was unable to determine whether a workstation was being actively used or whether it was inactive but not yet "timed-out." It was further not able to obtain information about the number or type of images that were being obtained, which rendered it of limited value in estimating the amount of network traffic. Additionally, it was not able to even establish the identity of the user because clinicians often failed to sign-off the system and permitted other clinicians to use their sign-on names and passwords. Finally, despite the fact that 15-minute intervals were chosen to prevent the program from decreasing system performance, this interval was relatively long and failed to capture those users who signed on for shorter intervals of time. This resulted in an underestimate of the utilization of the number of users outside the radiology department.

A significantly better approach would be to monitor all queries to the database for images from either the short- or long-term archives for each workstation. This log could be analyzed to deter-

mine the total amount of network traffic and the number and size of the images retrieved at each workstation for each user. An alternative approach would be to utilize "system agents" that also could be used to monitor workstation utilization and network traffic. Additionally, a local log could be kept at each workstation of the users who had signed-on and the number and type of images retrieved. This log potentially could be used to update automatically a central database.

CONCLUSION

A workstation monitoring program can be implemented, which automatically creates a log of workstation utilization that can be exported for analysis on a conventional spreadsheet or database analysis program. This methodology has several drawbacks as described, which make it a relatively crude tool in the prediction of peak and average network traffic and optimal workstation deployment. A large-scale PACS should include system administration tools that permit the creation of a utilization log and subsequent analysis of all image and database accesses for each workstation. This tool should not result in measurable degradation of system performance and should be run on an ongoing basis. Such an administrative tool could provide critical information to vendors for system design, to customers for system planning, and to users for system optimization and maintenance.

REFERENCES

1. Siegel EL, Diaconis JN, Pomerantz S, et al: Making filmless radiology work. J Digital Imaging 8:151–155, 1995

2. Leckie B, Smith D, Meyer C, et al: The MDIS workstation—An update of performance after nearly two years of clinical use. Proceedings of the SPIE Medical Imaging Conference, 1994

3. Siegel E: Parameters required to evaluate a filmless imaging system: Computer Applications to Assist Radiology. Carlsbad, CA, Symposia Foundation, 1996, p 508