

Fundamental Decrease of Time Loss by Immediate Access to Former Radiological Studies

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Summary

Goal:

To demonstrate the capabilities of a high-capacity PACS in avoiding prefetching and corresponding time loss by providing immediate access to the entire volume of former studies using only hard disks (RAID) as a storage media.

Methods:

Based on our local database we chose 150 anonymized patients with a newer (150 studies performed 2003) and an older performed (150 studies performed 1997-3/2003) radiological study. According to the kind of pictures (digital X-ray = DR, computer tomography = CT, magnet resonance tomography = MR) the selected studies were divided into three groups: DR-group (picture matrix 1760*2140), CT-group (512*512) and MR-group (256*256). Every dataset was loaded from our archive to the random access memory of two workstations in two different rooms, at two different times (morning: 7-11 a.m.; afternoon: 4-6 p.m.) and the loading time was measured.

Results:

According to the matrix of the modality we got for download speed the following medians (pictures per second): DR-group: a.m. 1.37 and p.m. 1.30; CT-group: a.m. 15.35 and p.m. 13.81; MR-group: a.m. 26.72 and p.m. 26.40. There was a significant difference in the download between morning and afternoon hours in the DR-group ($p=.002$) and the CT-group ($p=.027$) whereas in the MR-group no significance occurred.

Conclusion:

In a modern PACS architecture prefetching is no longer necessary.

Key words:

Picture archiving and communication system (PACS), images: storage and retrieval, RAID (redundant array of independent disks)

Introduction

Radiological examinations make an important contribution to the correct diagnosis and treatment of many patients within a hospital. With almost every patient a control study after treatment is necessary. Therefore newer and older studies should be available within short time at the workstation. At time most of the used PACS installations consists of a short and a long term archive for storage. As it was described by Samei and co-workers [1] the archival system is an important component of a PACS. The division of the system into short term and long term archives is primarily due to economic considerations. In recent years the rapid-access storage was too expensive to allow use on a long term basis.

In such traditional PACS systems some kind of prefetching algorithm is necessary. In the past many user's tried to optimize this prefetching algorithm [2] but the on-demand requesting of priors lasts around 5 to 10 minutes [3]. In a recent paper of Wirth and co-workers [4] postulated that problems of prefetching and waiting periods for demanded pre-studies would not occur any more by using only stable RAID systems as a storage media.

The Department of Diagnostic and Interventional Radiology at the Elisabethinen hospital in Linz (Austria) uses such a PACS since the beginning of the year 2003. Before installation of this system the most important demands were to get a PC-based workstation software, an easy database management and a rapid freely expandable storage media.

According to this requirement our department decided to implement a TIANI PACS System (Tiani Medgraph AG, Vienna, Austria) with the J-Vision Software (J-Vision 3.3.13, Tiani Medgraph AG, Vienna, Austria) for the workstations. This system offered us a novelty in picture archiving because normal hard disks are used as a storage media (picture 1). At time the advantages of hard disks are their high speed and cheapness. To guarantee the security of this system two symmetrical hard disk towers were installed and the pictures of every examination are stored at one tower and reflected on the other one. At last all exams are archived on magnetic tapes (recommended by law) which are independent of the daily routine. This means for the daily routine that we now in possession of a very fast system which offers all studies independently from the examination date in a very fast way. In our PACS there is no longer a difference between short and long-term archiving.

It was the aim of our investigation to describe and to compare the download speed of a modern PACS system when used in the morning and in the afternoon. Finally, these data should be the basis for the assessment if prefetching is furthermore necessary or not.

Methods

From the local databank 150 patients were chosen by random selection. Inclusion criteria: availability of both recent data (deriving from examinations carried out during the second half of 2003) and earlier data of the same modality and the same body site (deriving from examinations carried out between 1997 and 3/2003).

The selected patient data were divided into three groups (each group: n=50):

- 1) DR (= digital X-ray)-group: picture matrix 1760*2140
- 2) CT (= Computer tomography)-group: picture matrix 512*512
- 3) MR (= Magnet resonance tomography)-group: picture matrix 256*256

Each set of patient data consisting of a recent and a previous dataset was loaded from the archive into the RAM of the local work station and the loading time was measured with a stopwatch. This procedure was carried out at two different times of the day (morning = 7-11 a.m.; afternoon = 16-18 p.m.) at two workstations of the same components, situated however at different places. From each person the loading time of together 300 loading processes, each consisting of two studies, was measured and documented. The computer-aided ascertained data were subsequently evaluated statistically.

Picture 1

PACS system of the Department of Diagnostic and Interventional Radiology at the Elisabethinen hospital in Linz



Statistics

For statistical comparisons between the download speed in the morning and in the afternoon the Wilcoxon test (two-sided alpha = 5%) was used. This non-parametric test was chosen because the data were not normally distributed (Kolmogorov-Smirnov-test with Lilliefors significances, alpha = 5%). Data evaluation was purely descriptive without adjustments of the p-values. Consequently, significances at $p < .05$ reflect the probability of differences which can at best be used for generating hypotheses, but do not prove them. Descriptive data in the text reflect medians and quartiles (in square brackets).

Results

At both loading processes both datasets were completely loaded and the process was neither prematurely terminated (broken off) nor repeated. The final measurement values differ according to the IVP-matrix (DR, CT, MR) and the varying number of pictures (each group: $n=100$):

- 1) DR-group: 12 [10-13]
- 2) CT-group: 127 [97-192]
- 3) MR-group: 687 [382-1055]

The loading speed of the pictures (pictures/sec) was evaluated per group for a.m. (morning) and p.m. (afternoon) separately (each group: $n=50$):

- 1) DR-group: a.m. 1.37 [1.20-1.50], p.m. 1.30 [1.20-1.44]
- 2) CT-group: a.m. 15.35 [12.91-15.70], p.m. 13.81 [11.63-15.70]
- 3) MR-group: a.m. 26.72 [21.89-29.22], p.m. 26.40 [19.88-29.99]

Despite the main application of our system during the morning and the early afternoon there was a significant difference in the download speed at the DR-group ($p = .002$) and the CT-group ($p = .027$) and the pictures could be loaded faster during the morning. The different times of the day had, however, no significant effect with regard to the MR-group.

Discussion

As already proved in numerous studies, the daily radiological routine is hard to imagine -without a modern PACS-system [5-9]. Moreover, sources of errors in the administration of data have been significantly reduced by establishing a full integration with the KIS/RIS-system [10]. A modern picture archiving system clearly reduces the time required for the preparation of discussions about X-Ray

matters [11]. In our view the most important point is, however, that the previous pictures of a patient are available in order to increase the quality of the diagnosis [12].

Frequently not only the most recent examination is helpful, but also an examination made several years ago. For that reason prefetching-algorithms had to be determined in PACS-archives of former generations, so that pre-examinations could be loaded from the long term archive into the intermediate memory storage. By this measure it was not always ensured, that the desired pre-pictures were available, so that the time required for establishing the diagnosis was significantly longer. In our PACS architecture all examinations are stored on conventional (customary) hard disks, whereby the access time has been enormously reduced. The conventional long term archive does no more exist for the daily routine. In order to keep the out-of-operation (failure) time as low as possible all data are stored twice on two separate hard disk towers.

Each workstation now has a direct access to the complete picture archive and by using an easy databank system and the desired pre-examinations can be chosen by the user itself. As in our system a full KIS-integration exists, it was first feared, that during the main access times in our hospital (7 a.m.-2 p.m.) deficiencies in the performance could occur. To encounter this problem from the beginning, an own LAN has been planned for the radiology. The main line has a capacity of 1 Gbit and each of the 10 workstations can make use of 100 mbit for itself. That means that the same patient can be loaded at the same time and with the same speed also by two radiologists.

Nevertheless it was a little surprising, that the examinations from the DR- and CT-group could be loaded significantly faster during the morning. It is possible that this is related to the considerably smaller number of pictures compared with the MR-group.

At the moment the loading speed is very satisfactory for our routine work and one can no more imagine the clinical daily routine without the continually fast performance. Put the case that the number of pictures should further increase in the near future, it would be possible to raise the speed of the line to the workstations to 1 Gbit. By this measure the loading speed could once more be increased significantly.

Conclusion

In a modern PACS architecture prefetching is no longer necessary. In order to take precautions in an integrated network against variations in the daily

performance an own LAN for the radiology has to be included in the planning from the beginning.

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