Picture archiving and communication systems

An improved, clinically oriented archive concept for PACS: a substitute for the conventional film archive

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Abstract. Attention is drawn to a technologically mature and well-tested system that can be employed as the archiving component of picture archiving and communication systems (PACS). Capacities and performance are of orders of magnitude higher than currently available jukebox solutions. The hard- and software technologies plausibly allow for, and the vendor thus guarantees, unlimited data lifetimes. The accompanying software facilitates a very flexible integration into total PACS and hospital communication environments. System and medium costs are of an order of magnitude lower than for the optical disc jukeboxes per online Terabyte (TB). We present a rough conceptual framework for the organizational migration from a conventional analog to a totally digital archive using this technology. Based on rough cost estimates, this system should move comprehensive PACS into the near future, not only from the medical need but also from the technological and economical point of view.

Introduction

Picture Archiving and Communication Systems (PACS) is an increasingly often and controversially discussed topic in the literature, in workshops and at conferences. Should one buy PACS now or not?

In spite of the many obvious, but still theoretical, advantages of comprehensive PACS installations, most radiologists are still quite hesitant to take the big investment step for such systems. There are indeed some serious problems still to be tackled. Some repeatedly discussed topics are PACS functionalities in general; monitor resolution and quality and generally ergonomic human/machine interfaces for reporting and viewing softcopies on the monitor instead of hardcopies; topologies, capacities and speeds of the involved networks as well as teleradiology; interfacing with existing hospital information systems (HIS) and radiology information systems (RIS) as well as with slowly evolving hospital communication systems (HCS); design, installation and migration strategies (political, organizational, and technical) for PACS; definitions of standards for multivendor couplings and data exchange; primarily digital modalities and digital image acquisition; cost/benefits considerations; evaluations and assessments of existing mini- and entry-level PACS; sizes of data sets to be handled; problems of archiving; and prefetching concepts. One generally does have the impression that most of the discussed problems will be solved in the near future, if not in the laboratories of the vendors, then in the course of a few big pilot projects. Even the constant tendencies of better price/performance relations of the involved hardware work in favour of PACS installations.

However, for the problem of the archive and the enormous amount of image data to be handled if one aims for the filmless hospital, there have been to our knowledge no satisfactory solutions presented so far. The lack of convincing concepts for a migration of the complete conventional X-ray-film archive seems to us to be one of the main reasons for the mentioned procrastination. Prevailing concepts of PACS vendors concentrate on the electronic archiving of the images from the digital-image modalities only. Only to a small extent they provide for digitizing previous analog X-ray images of a patient when these are useful for comparisons with the new digital images as softcopies on the monitors. In these cases the digitized analog images will usually also be archived together with the primarily digital ones.

The archive-components of PACS currently offered in Germany are exclusively based on the so called jukebox technology with optical platters as storage medium. If one naively extrapolates the costs of such systems to include the total X-ray archive, one arrives at investment volumes which are difficult to justify with regard to return of investment.

Such limited and expensive archiving possibilities are confronted with the demands for PACS archives to en-
compass the total conventional radiological archive, analog images as well as primarily digital images, essentially in order to finally solve the problem of the enormous and unmanageable conventional X-ray archives, be able to simultaneously make any image of the archive arbitrarily available for several requestors in the house at any time, and reduce the amount of non-retrievable images from a devastating current 20\%–30\% to practically 0\% in the future.

In the following, we present some simple arguments as to why we find presently offered systems insufficient to solve the radiological archive problem. We then draw attention to an alternative, technologically mature and well-tested archiving system, which up to now has been relatively unknown in the radiology community. Also, the extreme need for enormous archiving capacities in radiology has been unknown to the vendors of the system we have in mind. We did find one reference to this type of medium in [1], where it is mentioned as one of many possibilities.

On the other hand, prevailing legal demands oppose these kinds of concepts, at least in Germany. If the governmental agencies do plan to promote the development of complete digital systems, then new legal guidelines to allow for this are necessary. These must take the technological evolution into account and favour digital archiving from the origin of the image on, considering, in particular, the higher achievable data security of digital systems in comparison with the large number of non-retrievable analog images mentioned above.

The essential goal of this paper is therefore to attempt to show that the path towards a totally digital hospital archive is already technically and financially realizable, if not even imperative. However, it must be pointed out that the present legal situation in Germany forces hospitals to maintain an analog film archive parallel to the evolving digital one. Needless to say, this leads to non-justifiable multiple financial efforts.

### Amount of image data sets created in a large radiology department

In Fig. 1, we show the amount of images produced per year by one magnetic resonance tomograph and two computer tomographs. These amounts of data seem manageable with the latest PACS concepts using the recently announced 1-TB (TB = 1000 GB) jukebox with 100 10.2-GB 12" optical WORM (Write-Once-Read-Many) platters.

However, roughly estimating the amount of data arising from digitizing all hitherto analog conventional X-ray images (Fig. 2), one arrives at yearly byte-production rates that in our opinion exceed all optical jukebox concepts presented so far. This order of magnitude roughly coincides with other estimates presented in the literature [1–5]. The exact values, of course, depend on the size of the digital matrices (desired resolution) and the relative amounts of large and small images.

In Fig. 3 the insufficiency of the current concepts is clearly demonstrated with respect to the small 33.6-GB and the larger 1-TB jukebox solutions. In both cases, the jukebox solutions are in our opinion unable to manage several years of images in online access.

At this point we draw attention to the fact that most authors have hitherto considered it necessary to maintain images online for only 1 year after image production. Thorough system analyses of radiology operations [2, 4] lead to such opinions, since the access frequency to images older than 1 year is today practically negligible. However, this low frequency could be caused by the high effort in the daily routine stress involved in accessing the older images. In particular, with a rather high probability of not even finding them, the radiologists refrain from trying in the first place. Many interviewed radiologists concede that in many cases they would very much prefer accessing images older than 1 year if this were easy and quick.

We therefore consider it important to favour concepts which allow for online access to 3–4-year-old images.