

Justifying the Picture Archiving and Communication System: General Considerations Based on the Trieste Experience

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WE PRESENT SOME general ideas about the reasons for introduction of a picture archiving and communications system (PACS) into a radiology department. Merits, benefits, and costs of PACS, in their widest meaning, are evaluated both in general and with respect to our actual experience.

Traditional approaches for justification, based mainly on economic and financial arguments, are widely considered to be more and more inadequate. This is even more evident in medicine, in which practice all benefits are hardly quantifiable in terms of profits.

We propose a multiattribute approach to the problem of justifying PACS. Attributes are parameters apt to describe the performance of a system with respect to some definite viewpoints. Different attributes may refer to different entities and be evaluated in different ways (qualitative, quantitative).

No comparison or tradeoff among attributes is required. Rather, the same attribute is compared for different systems or different situations. This implies an analytical attitude toward the justification problem rather than a normative one. We believe that such an approach is more appropriate in view of the present state of the art and of the actual diffusion of PACS.

We classify attributes to justify PACS into three broad classes: clinical, economic, and operational. Before we proceed to analyze such attributes, we summarize the conditions under which our experience with PACS is occurring.

THE TRIESTE PACS PROJECT

Since September 1988, a PACS (Comm View by AT&T and Philips) has been in operation in

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the radiology department of the University Hospital of Trieste, Italy. A research project is presently in progress aiming at providing factual evidence for evaluation of this kind of system with regard to operational, technical, clinical, and economic aspects. The general approach to this research consists of implementing and monitoring a PACS in a stepwise way, starting with an "entry-level" system connected to some digital modalities only to test the feasibility and effectiveness of the system in a radiology department, and to test the possibility of matching the PACS with the radiological system.

The Radiology Department

The new Hospital of Cattinara in Trieste has been in operation since 1984. It has 840 beds for 8 surgical and 7 medical departments. The University Radiology Department is the largest of four radiology centers of its health district. They cover a resident population of about 250,000 persons. The University Radiology Department has 21 examination rooms, 14 conventional and 7 digital: 4 ultrasound (US), 1 computed tomography (CT) scan, 1 angiographic machine, and 1 nuclear magnetic resonance (NMR) scanner. In 1988, about 100,000 examinations were performed, with a quite constant growth rate of 7,000 to 8,000 examinations per year since 1984.

System Configuration

The present configuration of the PACS in the Radiology Department of the University of Trieste consists of the following units: (1) a data management system (DMS), devoted to managing system operations and the archives; (2) an acquisition module (AM) devoted to acquiring the images from the modalities (in video format); and (3) a display workstation (DW), used to display the images for reporting or consulting purposes (two screens with 4 images each).

The system presently acquires all the images produced by a computed tomography (CT) unit (General Electric, Milwaukee, WI), an NMR unit (Philips, Eindhoven, Holland), a digital angiographic equipment (Philips), and the images rel-

ative to relevant abdominal cases produced by two ultrasound (US) units (Esaote Biomedica, Genoa, Italy).

The system is being expanded by acquisition of the following new units: two consulting workstations (CW), to be located in the same radiology department for consulting purposes; a jukebox for optical disks (89 plates); a film laser scanner devoted to acquiring images produced by conventional modalities; and another DW with acquisition capabilities, to be located in the radiology department of another hospital 6 km away and connected by optic fiber to the main system.

We next discuss several viewpoints from which the effectiveness of PACS may be considered. For each of the relevant problems we distinguish what can be expected in general, what we actually found out in practice, and what we intend to do in the future.

CLINICAL ASPECTS

Problem

Is PACS somehow relevant to diagnosis? The answer to this question obviously depends on how PACS is used. We identify two possible reasons why PACS may have a clinical relevance. First, interpretation of images by the radiologist is performed on a PACS console. Second, images may be distributed within the radiology department and to the requesting departments. Therefore, for interpretation on a PACS console, two aspects are worth considering: (1) performing the interpretation on a monitor rather than on film; and (2) having the possibility of retrieving other images from an electronic archive to facilitate diagnosis.

In General

One might expect better interpretations with PACS than without it as a consequence of the possibility of having images with a larger amount of information (digital v video images), image processing tools, and images from other examinations (such as multimodality). However, such benefits obviously require adequate technologies (interfaces, displays, storage media) to be implemented if they are to be available.

In Practice

We made some extensive tests regarding reporting CT examinations on our PACS. We found that our PACS images do not contain more information than films, because no digital interface has been made available to acquire images from the modalities; that image processing tools are seldom used by our radiologists in the current practice; and that the number of simultaneously available images is limited for us, which excludes the possibility of reporting on PACS examinations involving more images than the ones that are simultaneously available—Indeed, the possibility of swapping images on the monitors is not realistic in practice, which also excludes multimodality reporting; that within the above limitations, the clinical quality of the reports performed on our PACS is of the same level as with films; and that reporting on PACS requires training.

The clinical impact of the possibility of distributing (or transferring) images to the requesting departments is a quite critical issue that is heavily influenced by the specific way radiology is operated. Our approach is such that it makes no sense to transfer any image outside the radiology department without interpretation. According to this view, the interpretation may become more important than the image itself. Therefore, using PACS to distribute interpreted images is not relevant for clinical purposes, because the same results may also be achieved without PACS (resources, costs, and performances involved may be different).

In the Future

We plan to check the features of new equipment as it becomes available. The larger number of simultaneous images should extend the possibility of reporting other kinds of examinations on PACS. The possibility of transferring images within and among different radiology departments should facilitate teleconsulting, which in turn could also affect interpretation positively, at least indirectly by providing convenient means for training.

Clinically PACS may offer the same performance as the traditional means of image handling. Some potential benefits still require consistent technological implementation to be

actually worthwhile. Furthermore, there are technological limitations to the type of examinations that may be reported using PACS.

ECONOMIC ASPECTS

The economic aspects of PACS have been extensively studied by several groups. In this article, we consider only economic aspects related to the resources directly needed to operate PACS.

Problem

The problem consists of comparing costs with and without PACS. This depends on exactly what "with and without PACS," signifies.

In General

Clearly, PACS requires costs in terms of equipment, maintenance, personnel, and materials. In principle, however, PACS could produce savings in personnel and materials.

The possible scenarios for an economic evaluation may include the filmless Radiology Department, but may be influenced by different constraints (eg, legal aspects).

In Practice

We compared costs before and after introducing PACS. We experienced great investment costs and reasonable costs in personnel (one fulltime person) and materials (one optical disk per week).

No savings were possible. Indeed, all images acquired by PACS are still produced on film as well. Apart from the problem of legal acceptability of digital images, this dual processing is also necessary because outpatients are supposed to receive their films, whereas for inpatients, films are still the only means to distribute images. But apart from the latter reason (which could be overcome by placing terminals in the other departments), films still could not be dispensed with, because no device exists for our system that can produce a hard copy of any stored image. Therefore, a hard copy can be produced from the modality only at the moment of image generation.

In the Future

Placing terminals in the departments could allow us to save film, provided we solve the legal and technical problems. Unfortunately, we have

not yet done so and do not soon expect any savings.

Conclusions

PACS requires considerable investments and costs. Savings (in material and archive personnel) can be achieved only in the long term if some technical and legal aspects can be solved. Considering a reduction in the cost of resources as a basis for justifying PACS installation does not seem realistic.

OPERATIONAL ASPECTS

Problem

Operational aspects of PACS are more difficult to evaluate. To appreciate the impact of PACS from this viewpoint, we must compare the ways in which operations are carried out with and without PACS.

In General

PACS may be expected to improve the quality of operations by reducing the time required, reducing the resources required, and producing more effective results (eg, more reliable, more successful).

Some attention must be paid during such evaluations to distinguish among the effects directly produced by PACS and the ones that result merely from better organization of operations which might have been achieved without PACS. Indeed, PACS, like any other information system, necessarily requires operations to be somehow formalized and better organized. It is important to realize that such effects, although often triggered by PACS, could also have been achieved without it.

In Practice

The evaluation of the actual impact of PACS on the radiology department of the Trieste University Hospital is a consequence of two peculiar aspects of our project. First, since its installation, PACS has been used in actual everyday operations, not just tested in laboratory conditions. Second, the project is being implemented in a modular way. Therefore, the system available so far is only an entry-level system, performing all basic operations but still rudimentary in some tasks (eg, distribution).

We made detailed analysis of the way in which some of our specific operations are affected by PACS, including management of patient files, reporting, and availability.

Management of the Archive of Patient Files (Images and Reports)

Although the possibility of reliably retrieving patient files appears to be an appealing potential advantage of PACS, we discovered this was a minor feature in our case. Indeed, an extensive monitoring test showed that on the average seven of eight files requested in view of a new examination are regularly retrieved from the archive; the others are normally found in the department, and only 1 in 1000 is eventually missing. Therefore, we cannot justify PACS on the basis of reliability of retrieval because it produces only a slight improvement in an already satisfactory performance.

Reporting

We monitored reporting on PACS and compared it with the "manual" procedure using films on alternators. The operations with PACS are somehow more sluggish (20% to 30%). This performance is expected to be enhanced by technical improvements (image compression, faster transmission lines, distributed archives). This is a critical aspect, because radiologists view it as affecting productivity (in terms of reports per unit time).

Immediate Availability of Images

Availability of images in terms of time necessary to retrieve them appears to be a distinguishing feature of PACS that is particularly beneficial in that it makes consultations with colleagues from other departments more convenient, and such advantages are expected to increase as the optical archive grows. Facilitating and increasing personal contacts with the referring physicians is considered an extremely favorable effect of PACS.

Image Distribution

Our PACS is quite limited with regard to distribution of images, in particular outside the radiology department. Although this is again a consequence of the way in which our radiologists conceive their role, we have made some analysis

of the possible impact of PACS on distribution of interpreted images. In particular, we discovered that report typing constitutes the bottleneck in our organization; because reports are normally typed in the afternoon, having PACS ready to transmit the interpretation with images to the requesting departments makes little difference to manual transmission, which already makes them available the next morning after (ie, when they are actually used). Therefore, although PACS could speed up distribution considerably, the effect of such an improvement would be pointless owing to the circadian rhythm of our hospital operations. This consideration refers only to nonemergency cases, but because urgent examinations are handled manually in a different way, even in emergencies PACS is not expected to improve performance greatly.

In the Future

One of the most promising directions consists of integrating PACS with a radiology information system (RIS). This would allow us to better organize the management of patient data, speed up operations, and reduce personnel. As for reporting, the new workstations should narrow the gap relative to normal interpretation.

Conclusions

The operational aspects are the aspects that may be expected to be most affected by PACS. Apart from the burden imposed by the new activities needed to operate PACS, a set of old tasks (archiving, reporting, distributing) may benefit directly from PACS. Although such benefits are still far from being prevailing, some of them are perceptible and are expected to increase as technology improves.

CONCLUSIONS

Justifying PACS is not an easy task. Although some consistent benefits are self-evident for the medium to long range, immediate costs and resource requirements clearly are enormous. When (and whether) the benefits may be expected to overcome the detriments is a question that depends on too many external factors, such as technology evolution, user acceptance, and market attitudes to be easily answered.

The Trieste PAC System is evolving gradually. Its first phase, as an entry-level system, is over. The system will be expanded and we will acquire new equipment mainly devoted to storage and presentation functions.

The experience gained during the first phase has been useful both in setting reference figures to evaluate performance in the next phase and in devising plans for the evolution of the system. As for the latter concern, a major achievement is the belief that integration is a key factor for the

success of PACS. In the immediate future, connecting PACS with RIS will be a sensible step in this direction. In the longer term, a "horizontal" integration within the radiology department and among different radiology departments appears to offer the more effective perspectives.

The final aim of an integrated archive for all medical images of a city such as Trieste eventually must involve the concept of integration. A new project is being formulated to attain this objective.