Integration of
Health Professional Workstations in Hospital Information Systems

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Abstract: Health professionals at a ward need appropriate health professional workstations for being able to get all the information they need. It is the task of the management of a hospital information system (HIS) to provide access to the required information procedures in a uniform way. The paper gives a taxonomy of uniformity but makes clear, that uniform user interfaces are worthless, if there is no appropriate communication infrastructure at both the logical and the physical level of the corresponding HIS. Experiences in the Heidelberg University Hospital show, that pragmatic approaches can be successful.

1. Information Processing and Communication at a Ward and the Management of Heterogeneous Hospital Information Systems

In order to support patient care and medical research adequately and to keep information processing in hospitals economic it is the task of a systematic management of hospital information systems (HIS), to provide health professionals with
  (i)   the right information in the right place at the right time;
  (ii) the information processing tools, which are best suited for obtaining and delivering the information;
  (iii) the needed tools on as few media as ever possible;
  (iv) access to the tools at, or at least close to, the site, where the information processing to be supported has to be carried out;
  (v)   access to the tools in a convenient and uniform way.
The paper deals therefore with the consequences for such a management of HISs and with the experiences made in the Heidelberg University Hospital. In detail we want to answer the following question: "What are the consequences for the management of HISs if health professional workstations are to be introduced?"

2. Hospital Information Systems and Health Professional Workstations

Let us denote a hospital information system as the partial system of a hospital, which deals with the complete information processing and information storing of the hospital. That part of a HIS, in which computers are used as information processing tools, is denoted as the computer-supported part of a HIS [1].

As pointed out in more detail in [1] HISs can be considered as distributed systems consisting of co-operating objects performing information processing. In a three level graph-based model (3LGM) the objects can be classified as information procedures forming a procedure level, as application systems forming a logical tool level and as physical subsystems forming a physical tool level of HISs. Information procedures can be used by procedure accesses and application systems offer functions for their use. On the physical tool level there are special devices like personal computers or printers, which can be used by users as an entry-point to the HIS; those devices shall be called terminals in the sense of "end-point".

Reflecting 3LGM a health professional workstation is characterised by a personal computer, i.e. a terminal as defined before, a set of functions offered to users on that terminal and a set of accesses to procedures, which are thereby realised on the terminal or personal computer for example.

3. Qualities of Health Professional Workstations

3.1 Qualities at Procedure Level

Health professional workstations shall serve health professionals in getting the right information in the right place at the right time. As stated for example in [2] especially "point of care systems" in wards and ambulatory care units should therefore among others provide access to the following information procedures:

fundamental documentation and hospital-based diagnosis statistics; nursing documentation, patient record; entry of current demands for drugs and materials; order entry and results report; resource management; work flow management in ambulatory care; calendar management; medical knowledge retrieval; knowledge based support for diagnosis and therapy; admission, discharge, and transfer of patients; etc.

3.2 Qualities at Logical Tool Level

The requirements (ii) and (v) for health professional workstations in chapter 1 seem to be quite conflicting with each other. The conflict is up because especially in big hospitals the choice of the best suited tools will often result in the acquisition of heterogeneous application software products. Even if there might be no problem in acquiring software products with convenient user interfaces there is still a problem on providing a uniform access to the heterogeneous tools. In our opinion one can distinguish between three levels of uniformity at a health professional workstation:

level 0:   no uniformity,
level 1:   uniform access to application systems,
level 2:   uniform functions.

Let a personal computer be attached to the hospital wide communication network. This computer is thus providing the possibility of getting access to whatever application system of the HIS the user wants to use. Access is realised by explicitly choosing the appropriate servers and executing the appropriate operation system's commands. Let us consider such a health professional workstation as having 'no uniformity'.

A 'uniform access to application systems' can be achieved by providing a menu which enables to simply select an procedure access to a certain information procedure. An underlying software should then automatically find out the application system with the required functions and should then attach the respective server, find the application system there and start it.

The highest level of uniformity achievable in this context is to provide 'uniform functions'. That means to provide the same interface with all functions available at the health professional workstation. Thus, there is a uniform layout and a uniform "look and feel" in using the functions even if they are offered by different application systems. The more heterogeneous a HIS is at the logical tool level the more difficult it is to achieve this level of uniformity. Approaches for solving this problem vary from synchronous program to program communication to pragmatic solutions based for example on "plugs" [3].

3.3 Qualities at Physical Tool Level

Demands (iii), (iv) and (v) in chapter 1 are concerning qualities of a health professional workstation on its physical tool level.

Charge (iii) is always fulfilled by a health professional workstation per definitionem. This is because there should be only one media, i.e. a personal computer or another terminal, which provides all needed functions. As a consequence of demand (iv) health professional workstations have to be designed in a way, that they are capable of being employed in all areas of a hospital. Due to the usually restricted size of rooms for nurses and physicians at wards and ambulatory care units a space-saving and ergonomic equipment is required. Additionally, a data transmission interface for the connection of the workstation to the in-house communication network is necessary.

While a convenient access (charge (v)) at the physical tool level to the tools is still addressed by the requirements pointed out before, the uniformity of access can be supported at the physical tool level by an in-house standardisation of types of workstation computers and their operating systems. While choosing such a standard one should have to care of economical aspects and the requirement for the workstations being able to run as a client in client-server architectures.

3.4 Qualities of the Corresponding Hospital Information System

The demands (i) and (iv) are actually the essence of the demands having to be fulfilled by the management of a HIS. But exactly these demands cannot be achieved only by a good design of the health professional workstations. Moreover, this leads to requirements of an appropriate architecture of the HIS as a whole.

Considering how information can be exchanged between a health professional workstation and the rest of the corresponding HIS one should observe, that not only interfaces at the physical tool level but also at the logical tool level have to be taken into account.

Let on the health professional workstation be for example a procedure access to the procedure 'order entry and results report'. This procedure needs information, i.e. the lab reports, from a procedure 'laboratory diagnostics'. Thus there must be a communication interface at the logical tool level so that the corresponding lab application system can send messages which could be interpreted as lab reports. As a consequence the management of the HIS has to provide a means for communication at the logical tool level. According to our experiences a communication server on the logical tool level and the use of standardised protocols like HL7 [4] will support this task essentially. Last but not least data transmission has to be performed on the physical tool level, if the two application systems are installed on different computer systems. Thus, the HIS needs an adequate communication network.

As a conclusion one can see, that if a lab system has for example an ETHERNET-interface to the communication network but no means for sending reports appropriately and in a standardised manner on the logical tool level the best health professional workstation would be useless.

4.   The Health Professional Workstation MEDIAS in The Heidelberg University Hospital Information System

The Heidelberg university hospital comprises 62 medical departments. The number of in-patient stays reaches about 50.000 per year, the number of outpatients is about 200.000.

4.1   Health Professional Workstation MEDIAS

Health professional workstations in the Heidelberg university HIS are called MEDIAS (MEDIzinisches Arbeitsplatz System).

Qualities at Procedure Level
Comparing the following description of MEDIAS and the qualities charged for medical health professional workstation in section 3 one may be astonished about MEDIAS' little compliance to the demands. But our experiences have shown the considerable value of the procedure accesses for the users:

Clinical documentation, especially writing of medical and operation reports, providing pa-tient-oriented access for example to lab reports
An access to this procedure is realised on 110* MEDIAS computers. All operation reports in our hospital are written by using this procedure and thus can use all information of the op-eration documentation. About 32.000 lab and other reports per month are presented by this procedure. This means that about 33% of all our lab reports are now transported via computer support. An internal evaluation study discovered, that exactly the introduction of this proce-dure could increase the rate of reports being on the ward in time from app. 35% up to 75%.

Entry of current demands for drugs and materials
23* MEDIAS computers provide access to this procedure. As still being in the stage of in-troduction, there are MEDIAS computers on two wards providing access to a procedure for demanding meals

Medical knowledge retrieval
Access to medical knowledge is provided on 132* MEDIAS computers. Another internal study showe, that it is not only used in research but in app. 45% of 1887 observed sessions patient care was concerned.

Qualities at Logical Tool Level
MEDIAS provides level 1 of uniformity at a health professional workstation, i.e. uniform access to application systems. Although this is far from what is usually demanded in literature (e.g. [2, 5]) our experiences are satisfying. According to the study above only in 1% of the 1887 observed sessions the user interfaces were criticised.

Qualities at Physical Tool Level
In july 1995 there were about 200 personal computers running as MEDIAS computers in the Heidelberg University Hospital. While up to now most of the computers run under MS-DOS we will now stepwise change to MS-Windows.

4.2   Heidelberg University Hospital Information System

Integration of MEDIAS in the Heidelberg university HIS is possible because there are ap-propriate means for communication both at logical and physical tool level as mentioned before [6]. On the logical tool level there are about 40 autonomous application systems having com-

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* as in july 1995

munication interfaces with the communication server HeiKo. All those application systems use an in-house communication standard, which is an HL7-like communication protocol (see chapter 3.4). In the beginning of 1995 the communication network on the physical tool level connected the computers of all application systems mentioned before and provided 2845 sockets for workstations all over the hospital. Especially all wards are equipped with such sockets. Therefore, all MEDIAS computers can now be situated on that sites, where they are needed.

5. Results and Discussion of Related Approaches

The responsibles for the management of the HIS have to provide on the physical tool level:
- an appropriate communication network (a modern optical fibre backbone will be helpful but is no 'conditio sine qua non'),
- commonly used personal computers with connection to the communication network,
- connections to the communication network of all computers being the basis of application systems, which have to deliver messages to the workstation (for example computer of a lab system).

They have to provide on the logical tool level:
- an application system which runs as a communication server,
- application systems which provide the functions for presenting the needed information to users and can be accessed as easy as possible from the personal computers mentioned above,
- communication interfaces between the communication server and the application systems for presenting the information,
- communication interfaces between the communication server and the application systems for delivering the information (for example lab system).

A lot of other papers dealing with health professional workstations are now available in international literature and a good overview of the current state of the art can be found in the proceedings of a concerned IMIA conference held 1993 in Washington, DC [2]. The most exciting concepts, which aim to achieve not only level 2 of uniformity but real functional integration [5] of heterogeneous application systems on the logical tool level seem to be those labelled by HERMES [3] and HELIOS [7].

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