Mobile documentation with integrated PDAs – a real world example

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Abstract: Different solutions have been proposed by both manufacturers and institutions to tackle the ever-growing problem of documentation in the hospital. With the arrival of mobile technology new solutions are developed to support medical staff in their daily work.

meditrace is a PDA-based, integrated system, permitting to document medical findings at the patient’s bedside. The first pilot installation is running since 2002 in a ward for internal medicine of a German hospital.

We first present an overview regarding the documentation issue and the meditrace product itself. Then we report about the pilot installation. We give details about integration, expectations, problems and success followed by a short outlook concerning possible future development.

Keywords: Medical records, Handheld computers, PDA, Quality of health care, Mobile documentation

1 Medical documentation

1.1 Documentation today

Documentation in the hospital is a well-known issue which gained momentum in the early nineties. The underlying mechanisms being the tendency of modern societies to shed away from blind trust as well as the need for cost control, we can expect the issue to be around for the foreseeable future. Seen from the perspective of a doctor the main reasons to document the patient history are thus mainly forensic and socio-medical [LU99].

During the documentation process the complete data of history taking, initial diagnosis, findings and therapy constitute the patient record. The record is normally summed up in a release letter which insures treatment continuity through other actors of the medical system. One of the most important parts of the record is the continuous documentation containing the results of initial history taking and daily patient visit. The terminology used is the one of standard medical expressions. No further hospital-independent standardisation takes place, there is in particular no classification which would be valid in general to structure the continuous documentation [Dah84, Dim02]. The only frame is given by unwritten rules inside the hospital or the ward and maybe ready-made forms for history
Due to the so-called “cost explosion” in the health sector in Germany steps were taken through the GSG law of 1992 to make a posteriori audits possible based on standardised documentation. To this effect it is required that hospitals document facts like admission and discharge dates, reason and type of admission and discharge, but also initial, primary, secondary and discharge diagnoses. The diagnoses are coded using the ICD (International Classification of Diseases) [Icd00]. The ICD being a systematic classification, which has been changed and extended many times, it is virtually impossible to know all the relevant codes by heart. Correct coding of the diseases treated requires in all but the trivial cases special coding software.

All the coded diagnoses and procedures must be transmitted in time to the organisations bearing the treatment costs like health insurance companies. A special service called MDK (Medizinischer Dienst der Krankenkassen – health insurance service for medical controlling) checks the data against the length of the treatment in the hospital or the corresponding flat rates. Since 2000 a catalogue of criteria is used to standardise the checks. The better the documentation fits the requirements of the AEP ( Appropriateness Evaluation Protocol), the faster the checks can be done [BH00, Myd02].

In addition to those requirements, quality control has also been introduced into the hospital by the means of protocols, requiring the entry of standardised data.

Not the least since the events of HIV the transfusion law requires that all products derived from human blood or blood components must be documented for each patient with their precise ID number [Trf98].

Most of the time all this documentation work is done retrospectively, “when there is time”, and multiple times (for the different forms), based on only part of the information, which was initially available, the rest being not documented and thus forgotten. Some estimate that the documentation chore already today eats up to 4 minutes out of 5 allocated to any given patient, so that 5 minutes spent with a patient mean 20 minutes of paper work [Fli00].

1.2 Documentation in the future

From the year 2003 onwards, reimbursement for hospitals in Germany will be based on a DRG (Diagnosis Related Groups) system, which requires still more attention when coding diagnoses. While today the omission of one or more secondary diagnoses has no immediate consequence, in the future all diagnoses potentially influence the reimbursement. The complete and accurate documentation of all diagnoses will become the precondition for a reimbursement based on actual treatment [RR01, WHS01]. This puts a further burden onto the doctor. Since only half of the ICD is relevant in this context, ideally the doctor would need to know the ICD as well as the grouping algorithm to achieve correct documentation which also makes sense economically.

Already today’s requirements sum up to a huge amount of forms and data, which must be handled by the treating doctor. Since the requirements are bound to stay, the time
fraction needed for documentation will change for the worse with more documentation requirements already in the pipeline today [Sgb02].

1.3 Solutions to the documentation requirements

Given the current reality as well as the foreseeable future it seems of utmost importance to support doctors and nursing personnel in their documentation work. The support becomes thus a prerequisite for a good team.

There are several ways to implement this support, we will just sketch some of them. Hiring personnel for medical coding is one way to attack the problem. Such documentalists take the information written down by medical and nursing staff and extract or produce the data for billing, quality control, required forms or any other report. While the idea is tempting, since it separates reporting and coding tasks from the healing process, it is also dangerous. It has been shown [SBW02] that even a very experienced medical controller is not able to completely reconstitute the information for DRG coding from the notes of the medical staff. Some information is lost forever if not documented right away in an appropriate way. So even this solution depends on good documentation and solves only part of the problem.

Computers come to mind when discussing subjects like information storage and processing. They can certainly help processing the data stream and the electronic patient record has been around for a long time, interpreted and reinterpreted by every vendor over the years. Yet is it seldom more that just a folder around a broad set of files, pictures and documents in different formats with no real relation among them. Efficient analysis is out of question, since most information is present in free format, which cannot easily be processed.

Support for continuous documentation requires special functionality specifically tailored to doctors and nurses. It can be implemented as an extension to an existing HIS (Hospital Information System) or as a separate system integrated into the general IT architecture of the hospital. Both kinds of software become increasingly available on the market where a focus shift takes place from classical HIS to specialised workplace systems.

One way to use the new possibilities is the support through stationary computer systems on the ward. Doctors and nurses can enter the data into the system, further data processing is leveraged through the system itself, multiple data entry is not required. This is a big improvement and not without reason many systems focused onto doctors and nurses hit the market currently. Still the functionality of those solutions is often somewhat limited since the information is neither structured nor standardised. They also suffer from the fact that data entry is not done on the spot, but retrospectively, when doctors and nurses have time to go to their offices. Some information will inevitably be lost due to the delayed data capture.

Another possibility is based on mobile computers. They can be carried around, so that data can be entered right away, before anything gets lost. Well integrated they can offer a good tool for the daily use when seeing the patients. Of course the screen is smaller and the user interface must be well devised to guarantee usability. If the mobile devices are small
enough, this technology also offers an additional advantage, which neither of the first two solutions have: the data are always in the doctor’s pocket, be it during day or night duty, when one is called to an unknown patient and happy to have the current findings close.

In the category of mobile solutions different families can be found. Solutions range from a pure HIS, which just runs on a notebook or on tablet PCs over systems using scanners and bar codes finishing with PDAs which are either stand-alone or integrated into the IT infrastructure. Solutions from all those families may currently be found in the market. Mobile HIS systems have the advantage of continuity in the user interface and access to the full functionality but the disadvantage of bulky devices and thus only limited mobility. Scanners are handy to use, but mapping findings and activities to bar codes is cumbersome. PDAs have the advantage of being light and always ready to be used, but can only offer a subset of a full stationary system.

We will concentrate in the following on the family of integrated PDAs and introduce meditrace, a PDA-based system focused on documentation of medical findings.

2 meditrace

2.1 Introduction

Taking a step back, any documentation system should offer the following qualities: immediate, practical, standardised, structured, intuitive, customisable, rapid, secure and integrated. Specifically for mobile systems on PDAs a good integration into the HIS, which enables downstream support for the subsequent tasks, is an important precondition.

meditrace (http://www.meditrace.com) is a completely new development which aims to meet the criteria listed above. It is based on modern yet reliable technology, has a front-end component which is running on a PDA and a backend which exchanges data with the HIS or any other data processing engines.

Doctors and nurses carry the PDA in their pocket, ready to look up or document any information which might arise during their daily work, right on the spot. A specialised user interface ensures efficient use of the device despite the limited size.

2.2 Hardware

The base requirement when developing meditrace was the ability to capture data anywhere anytime. In addition the application potentially needs to store big amounts of data, which results in memory and processing speed requirements. The choice was made for the SYMBIAN OS (formerly EPOC), which is well known, very stable and has a history of several years on mobile devices. Classical PDAs are mostly produced by Psion Teklogix (formerly Psion), devices with integrated mobile phones by Nokia and Sony-Ericsson.
Among the PDAs different form factors are available, from the well-known keyboard equipped organizer to sub notebook size with colour VGA screen. Special devices without keyboard, which fulfil the IP67 specification and are watertight and dust protected like the Psion Teklogix netpad are also available with and without bar code scanners. Mostly used is the keyboard equipped Psion MX5 pro which is able to store the complete ICD10 and current ICPM along with program and patient data. User interaction is supported via keyboard or touch screen. But devices like the netpad also meet strong interest, especially for scanning blood product bar codes and for use in rough environments.

2.3 Software

The PDA software is written as specialized C++ code running currently under SYMBIAN OS. The medical contents of the dialog trees, which are used for data entry, are not hard coded but stored in a XML file, read by the program on start-up.

The backend software runs under all major operating systems. It comprises a synchronisation server as well as a database connector which stores data in any usual SQL database. The backend also supports data notification, which allows the implementation of event-driven data processing. Processes that have issued notification requests can operate on the data as soon as they arrive. The system architecture is shown in figure 1.

For security reasons data are stored encrypted on the PDA client and are also transmitted
encrypted to the sync server. The client program requires a login with password. The device may thus be used by several persons, all users having only access to their specific data. This allows for a user based access definition to sensitive data.

Authenticating the user on program start-up is also used for automatic data set definitions. A doctor overseeing one ward during the day might be on duty during the night and then responsible for several wards at the same time. At night synchronising will automatically give him all the required patients. When synchronising again the next morning, only the patients of his own ward will remain on the PDA.

2.4 User interface

meditrace structures are translated as shown in figure 2, but not all tree versions are translated yet. The following screenshots will thus be in German. All data entry is done through hierarchical dialogues. The first example in figure 3 shows the documentation of the subjective view of the patient suffering from a cough. Choosing the dialogue “Thorax” it is possible to document “Husten” (Cough).

Additional specifications are provided for some of the entries. When clicking on “Umstände” (Specifications), a new dialogue opens up, offering a wide choice of additional information. Figure 2.4 shows that the cough becomes worse when smoking (“Rauchen”). Any common type of widget is supported, like radio buttons, check boxes, choice lists or free text editors. The latter should only be used for additional notes though, since the information entered can only partly be processed automatically.

Quick visual feedback of the information entered is provided at the patient view level through a picture of the human body. There is the possibility to zoom into the picture for more details. The whole screen can also be scaled for better visibility.

Even if it is possible to view old and current data on the PDA, a good overview over all the patient-related data is better obtained on a stationary PC with a bigger screen. meditrace
provides the quick look into existing data but is really focused onto capturing new data where they arise. This is the answer to the fact that the current problem in the wards is often not the lack of a complete overview regarding the data but the lacking ability to enter clinical findings in an efficient and standardised way.

2.5 Data

An important goal during the realisation of meditrace was to achieve an open architecture by using open standards. To this effect all data are exchanged as XML documents, even between the different backend components themselves. This ensures that any other program is technically able to access the same data.

In other terms this means that data can be changed, fed and retrieved by any program able
to process XML documents, which are independent of the processor and the operating system. In the present installation this mechanism is used to exchange patient base data over HL7 with the HIS.

Internal data storage of the captured data in the database is realised through so-called MDTC (MeDiTrace Classification) codes, which provide the possibility to extract information quickly and compare it with other systems either directly or through mapping tables. Comparable concepts are used by other classifications [Icn02, MTZ01]. A mapping table where over 1000 MDTC codes are mapped to about 400 ICD codes is provided with meditrace.

When new data arrive, special handlers are notified which generate additional data. One handler for example generates ICD proposals from the MDTC codes, which can later be acknowledged by the doctor. Once the data generation is finished, the HIS is notified about the new data.

2.6 Configuration

The use of standard XML formats together with an XML-aware editor provided with meditrace allows the customisation of the dialog tree structure. While a tree with over 1000 entries is pre-configured and covers most of the requirements for daily work, any additional information can be integrated in the editor shown in figure 5. Likewise unnecessary fields can be removed and the whole structure can be rearranged.

The whole configuration process requires no programming skills and no knowledge regarding the internals of meditrace. No recompilation of the program is required either, since the XML file serves as a dynamic configuration base. Memory structures and user data are automatically derived from the XML data structure in the client.

This approach gives the hospitals the power to tailor the application to their needs without the high cost usually associated with tailor-made solutions.

2.7 meditrace summary

Let us have a look back and see how the requirements for documentation systems given earlier are met by meditrace:

**Immediate:** SYMBIAN OS based PDAs are well known since several years and highly reliable. Opening the PDA is sufficient to start the documentation process.

**Practical:** Due to the light devices they can be carried easily.

**Standardised:** Data entry is done in data trees, which are defined once and are used in the same way by everybody. The data themselves are stored in a classification and can thus be used for later analysis.
structured: The trees are hierarchical, so that the relevant place for data entry can be found easily.

intuitive: Tailored to the PDA, the program is intuitive to use even with minor training.

customisable: All data trees can be customised by the hospital or the ward to suit their special needs.

rapid: The program has a special user interface, which is specially designed for rapid data entry.

secure: All data are stored encrypted following AES on the device and during transmission.

integrated: Special backend mechanisms and the use of XML documents provide the possibility to exchange and post-process data with other systems. Base data are exchanged via HL7.
3 meditrace pilot

meditrace has matured over the last two years [Wal02, KH01] and has been integrated into the HIS system “fd-KLINIKA” provided by fliegel data, Höxter, Germany. Late last year the next phase was started with the preparation of a pilot installation. Since the end of January 2002, meditrace runs in the ward for internal medicine of “Städtisches Krankenhaus Seesen” (http://www.krankenhaus-seesen.de), a medium-sized hospital in northern Germany. The introduction of the system, which contains both the mobile component and additional functionality in the HIS system itself is a big step closer to a complete medical record.

3.1 Environment

The hospital has about 170 beds; two wards are for internal medicine with together 76 beds. Seven doctors are working on the ward which focuses on vascular medicine, cardiology and gastro-enterology.

3.2 Pilot definition

The meditrace pilot was designed to replace all hand-written visit documentation. The decision not to use parallel paper-based documentation was taken so that the effects of the new system could be watched in a real-world scenario. It was limited to the doctors working on the ward.

During normal use the doctors arrive in the morning and synchronise their PDAs using the IR interface. New patients are then visited and documented on the PDA with the help of meditrace. Once the visit is terminated, the PDAs are synchronised again, allowing all doctors to access the data. On subsequent visits the data captured in the last visit are copied and then edited. This allows to document the new status quickly, since only deltas need to be changed. When data need to be entered during night duty, they are processed in the same way and are available for the treating doctor the next morning. On patient discharge all data are presented by the HIS on a stationary PC, thus facilitating the discharge letter.

Expectations concerning the new system were better internal communication, a decrease in time used for documentation and documentation better suited for DRG coding. On the technical side the expectations were running high concerning a stable system and easy use of the software.
3.3 Time frame

First preparations for the pilot scheme started late last year. During December 2001 and January 2002 the dialogue trees were adapted and technical details were defined and integrated into the meditrace software. The software was installed mid of January and on the 24th a 3 hour training was held for the end users. A special training was given to one of the doctors acting as a privileged contact person as well as to a member of the IT department. The pilot started on January the 28th and was scheduled to run for about 2 months.

3.4 Technical details

The PDAs used are of type Psion 5MX, each doctor using his own device. These devices have 16MB RAM, a greyscale touchscreen (resolution 640×240) and weigh about 350 grams. The memory is sufficient to hold the complex tree structures along with the data. Synchronisation is done via infrared-network-adapter from Clarinet which are placed at two central locations inside the wards. These adapters are integrated into the existing Ethernet LAN. The synchronisation server processes were installed on an existing host running Microsoft Windows NT 4. Since a Microsoft SQL Server 7 was already in use for the existing HIS, this database was also used for meditrace.

3.5 Integration

For the pilot meditrace was fully integrated with the existing HIS “fd-KLINIKA”. Additional fd-KLINIKA modules for medical documentation were installed at the hospital. A HL7-interface was configured which automatically transfers any changes in the patient data to the meditrace system. The data captured by the doctors during their rounds are synchronized from PDA to database by using infrared-adapter. Inside the meditrace framework an event-based mechanism processes the data further, from the medical findings matching ICD codes are extracted automatically. All data are subsequently transferred to the HIS system through a notification system, which allows immediate data processing.

Further manual processing is done by the medical staff inside the module “medical documentation” of fd-KLINIKA. Here the doctor may accept or reject the proposed ICD codes, which were extracted from the visit data. This is also the place where the documentation is summarised in a release letter, which is then sent to the GP. The HIS supports this task by offering an overview of all continuous documentation.
3.6 General pilot results

Some of the doctors initially were afraid that a new system with a fixed input structure would limit their possibilities and enforce them to work the way the system requires it. They doubted that the system could support them in their usual way of work. This is very understandable position, since many doctors have their very personal way to integrate and document data.

During the every-day work with the new system it turned out that the new system indeed comes along with a major change in daily work and requires adaption and time to get used to. Most doctors were comfortable with the system after about 14 days.

It also turned out that the configuration of the different dialogues and hierarchies is of great importance. There is no way around a close cooperation with users to make sure that they will find what they need for their everyday work. It also requires by the physicians an open attitude to shape the system for the benefit of all end users. Time should be planned to go through the structures and a pilot installation is very recommended to make sure that nothing important has been overlooked.

3.7 Difficulties

On the technical side the software running on the PDAs as well as the server processes were stable and reliable during the pilot. There were some technical problems regarding the handling of the mobile devices, e.g. users forgot to change the batteries. Some data synchronisation problems appeared, which were due to organisational misunderstandings. It also turned out that the number of infrared-interfaces was too low to allow frequent and easy synchronisation.

Especially in the initial phase some organisational processes were not handled correctly by the system. Sometimes patients were transferred from the internal ward to other wards due to space shortage. These patients were not displayed on the PDAs any longer because the technical classification was based on the location of the patient, not on the ward they belong to. This situation was fixed by modifying the configuration in the central database.

On the medical side not every detail could be documented the way the doctor wanted to. This is the downside for structured and standardised documentation, which is enforced by the input structure of meditrace. Some users wanted to have more free-text input fields to enter additional information. This is understandable but also a problem, since the information entered there can not be processed automatically. Since the presentation of the medical data in the medical documentation module of the HIS is closely linked to the internal representation inside the database, the presentation on the screen is only of limited use to the end user. These requirements can easily be realised in future releases of the software, since both meditrace and the fd-KLINIKA system are quite flexible.
3.8 Success

After a transition period of several days, the users experienced the advantages of the new system. Most of the problems which occurred during the pilot scheme, were fixed immediately. Some bigger modifications will be discussed together with the medical staff after the pilot phase (April 2002) and integrated into the next software release.

According to the doctors the overall flow of information on the ward improved clearly due to the automatic data synchronisation. Writing the final documentation became easier since all the captured data are accessible inside the stationary documentation module and even inexperienced users could easily use the new technique. There was a general feeling among the users that the loss of important information decreased by using the new system.

Not expected by the users beforehand was the added value through improved communication. The system being integrated into their normal work flow, findings were available immediately and improved the turn-around times especially in the therapy area by distributing feedback immediately through the synchronisation. In general there was an big benefit through an improved flow of information.

3.9 Outlook

After the successful pilot the hospital intends to use meditrace on a regular basis. It is planned to extend the usage on one hand to nurses, on the other hand to other wards (gynaecology, surgery).

While the usability of PDA-based systems for medical documentation is now clearly established, some issues need further work in the future. The most prominent one is the problem of data integration. meditrace documents information with high granularity on a level which we call atomic. All atomic data captured are “hard” in the sense that they correspond to real facts. While this is often appropriate for the nursing environment, doctors tend to integrate information and to document only their conclusions. To retain the advantage of automatic data analysis one would need to re-decompose the integrated information in order to populate the atomic level.

In this process the data generated would be “soft” in the sense that they originally are not atomic data, but extracted from integrated information. Retaining the forensic validity of the documentation in this context is certainly a challenge for future versions of meditrace.

4 Summary

In this article we have given a brief overview over the development of documentation requirements and the practical consequences for the medical staff in German hospitals. Several solutions to support doctors and nurses have been sketched.
We have then focused on the support of documentation based on mobile devices. Several criteria for such solutions have been given and we have presented meditrace, a PDA-based solution by KI AG which can be integrated into existing HIS systems. A detailed description of the possibilities of the system and the system architecture itself has been made and it has been shown how meditrace attempts to fulfil the criteria listed earlier.

In the last part we have presented the pilot installation of meditrace integrated into the HIS fd-KLINIKA in the general hospital in Seesen, North-Germany. The technical frame as well as the integration into the existing IT architecture has been described. After a description of the pilot goals and the expectations linked to it we have shown that a short time frame is sufficient to introduce meditrace into the daily workflow. We have reported about the results of the pilot installation and described where the problems and the benefits have been found. We conclude that although improvements need to be realised, meditrace in combination with the HIS is well suited to support doctors for the documentation of the daily visit and the subsequent paperwork.

**Bibliography**


