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Mobile Computing On Telemedicine And Distance Learning: Application On Surgery Pediatric Oncology

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Abstract

This paper presents a mobile-computing tool that helps leading expertise knowledge of childhood oncology to many places over the country. The tool is composed of independent applications that run in different platforms and yet communicate. A system for following patients' treatment on-site was implemented for handhelds, PDA type. With this system, the tool acquires the mobility needed to make distance training in Brazil easier. Information about the patients is registered in the handheld device and then transferred to a consolidated database in the Internet, through a double-way synchronization process. A client application for personal computers integrates this project, surpassing PDAs limitations, regarding certain data entries and report printing. The server, which provides access to the corporative database, was built on Microsoft's DCOM distributed-objects' system. The database is supplied with information obtained from patients, physicians and the group coordinator, with the purpose of building a solid knowledge base on pediatric oncology.

1. Introduction

Though cancer is a conceptually complex disease, most people are aware of how lethal it can be. According to a research made by the International Outreach Program, in 1999, cancer has reached more than 10 million people in the world, making 6 million victims. Estimates for 2020 get to 20 million cases of cancer in the world with 12 million deaths. Specifically children, 240 thousand new cases are verified each year.

Despite the development of therapies, surviving rates for children with cancer have increased only in developed countries (approximately 75% of the cases). Considering the whole world, less than 30% children have access to modern treatment.

Some organizations are aiming to reduce the lack of knowledge that prevents physicians of many countries from treating childhood cancer. The idea is to disseminate progresses achieved by developed countries to the ones with more limited resources.

A mostly suitable example is the International Outreach Program of St. Jude Children's Research Hospital (Memphis, USA) that intends to build a clinical and teaching/learning-integrated environment addressed to the matter.

The Brazilian Coordination of the International Outreach Program aims to raise the survival rate of the children with cancer and to identify new research opportunities, through education, training, knowledge and technology transfer.

Some times, the knowledge interchange environment adopted in Brazil might be described as follow: the patient is seeing by a physician, which participate on any knowledge interchange program; the physician fills in a record about the patient and the situation observed. Then, after analysis of the patient's condition, a diagnostic is made and treatment is prescribed. Each of these steps is related, through e-mail, to the coordinator. Also, by e-mail, it is up to coordinator to help in the patients' treatment, orienting the students in new medical practices, verifying eventual errors in diagnostics and recommending the most suitable treatments.

The procedure described avoids the isolation of the attending physician, who may receive information from the coordinator or from other physicians that participate the program. However, the necessity of improving the interchange method is of common sense, mainly concerning standardization of information to make analysis easier, formation of a database, faster and easier knowledge transfer between the attending physician and the rest of the group.

Characteristics desirable in the new method: a better procedure related to collecting patients' data, eliminating the need of transcribing from paper forms to magnetic means, standardization of information in electronic forms and availability of the consolidated knowledge in a accessible environment, such as Internet (and all the inherent facilities).

The work here described helps the coordinators of the knowledge interchange programs to develop his activities of teaching, following, supporting and assessment all over the country, from wherever he stands. Applying main concepts of PBL (problem-based learning) [1, 2, 3] methodology and teledidactics (branch of didactics dedicated to distance learning) the coordinator offers distance training and globally integrates efforts in combat to diseases.

In this way, with the objective of making easier the activities of the students and coordinator, some available tools for distance learning through the Internet are integrated with a mobile system of data acquisition and display. The integrated system allows the students to make the necessary records of their activities in a centralized database, whose information can be used afterwards for consulting, including by the rest of the group. To the coordinator, there is the facility of accessing up-to-date information about the students' activities, and also interfering whenever convenient or necessary. PDAs (Personal Digital Assistants) are used to make the remote acquisition of information automatic, from the patients being treated, the procedures already applied and the ones to be applied. Then, this information is made available in a database in the Internet to the rest of the group for a possible discussion and to the coordinator of the program for following, support and evaluation of the developed activities.

This technique also allows the coordinator to intercede in patients' treatment, with suggestions or even instructions of what should be done, and to evaluate the students' learning curve during the time.

The work presented in this article, called PALM-TUTOR, might be considered collaboration to organizations and programs of the knowledge interchange, allowing knowledge to be diffused among various professionals and entities.

2. Methodology

Distance-teaching programs for medicine propose to spread knowledge to various regions, providing training to physicians willing to become experts in certain areas [4, 5, 6, 7]. In order achieve that goal, the program coordinator needs to manage the procedures to be taken by the participants during patients treatment, orienting, following and evaluating them.

To carry this out, an integrated-system, which counts on a centralized database with information about patients (identification, diagnostics, exams, procedures, surgeries and complications) and comments of the physicians/coordinator. The database was structured during the development of the system and the members of the program continuously supply it. To keep all this information up-to-date, a remote data acquisition system, using mobile computing (PDA), was implemented, allowing users to entry data to the system on-site and in the moment that things happen. A similar system was developed to run on personal computers, with the difference that, in this case, the user accesses the data directly in the centralized database, through an Internet connection. Moreover, the user is able to, beyond insert, update and delete data, print various reports of one's interest. As the data acquired for the PDAs is in standalone databases and as the centralized database can be updated by the application available in a personal computer, an application was developed to synchronize these databases, in such a way that information is updated in the various ends of the process.

Summarizing, the system was developed in five tiers, how shows the figure 1.

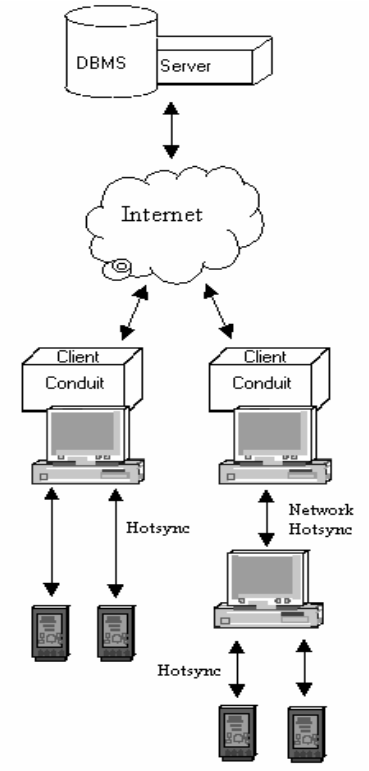

Figure 1: Complete System

2.1. Centralized Database

The centralized database was modeled in such a way that makes the implementation of remote data-acquisition and synchronization systems easier.

As there is a necessity of controlling who is the proprietary of one determinate record, all tables are related to the user's table, one user could have zero or various records, one record could to belong to only one user.

All discussions, surgeries, diagnostics, and consults are related to a determined patient.

2.2. Application Server

The application server coordinates and processes the client-applications' requisitions handling all details of dataset definitions and interactions with the database server (DBMS).

As both the application server and the DBMS are remotely located in relation to clients – out of the domain of a local area network (LAN) – some means of communication between those tiers was necessary. The adopted solution, due to its low cost, was the Internet, using HTTP (Hipper Text Transfer Protocol) protocol.

There are various ways of supporting the communication of objects between computers through the Internet. DCOM (Distributed Component Object Model) and CORBA (Common Object Request Broker) are the most used ones.

To develop the proposed system, DCOM[9] was chosen.

2.3. Remote Data Acquisition System

Most of the work of a health student is performed "on-site". In case of physicians and nurses, many activities are developed in bedside or in surgical centers.

All these activities produce information that needs to be registered, not only for scientific purposes, but also for administrative and legal ones [7].

Very often, the student also needs previous information about the patient, before submitting him to a determined procedure.

Many questions also may be similar to other cases already solved and registered in database.

In order to avoid rework – information and questions about patient treatment is acquired, transcribed to paper and the typed to the coordinator's e-mail – a remote data acquisition system was developed. This system was built on mobile computing and runs in PDA devices, PalmOS® compliant.

Despite of all qualities of the PDA concerning mobility, the device shows some limitations. In this work, the major problem was related to printing reports.

Printing data from a PDA is possible, nevertheless, the system developer, bit by bit by bit by bit, performs all printer control making complex report (containing e.g. images, various fonts) printing almost impracticable. Moreover, only a printer with serial or infrared communication could be used.

Actually, many different reports have to be printed, according to the hospital's needs and within its standards. Nevertheless, the emission of these reports can be performed in specific moments – they don't have to be printed "on-site", close to the patients.

As the user will need to synchronize the data in his PDA with the centralized database in the Internet and as the responsible application for this sync will run in one of the various PCs with Windows platform available in the hospital environment, this restriction was turned into advantage to make available in these same computers one version of the system, similar to the one developed for PDAs.

The system developed for PC has all the functionalities the version for PDA does. Moreover, it has options for printing various reports and for complementing patients' register with less relevant data – now using a keyboard instead of the PDAs' graffiti.

2.4. Data Sync Application

Due to the mobility of the PDA, all data in it is local. Therefore, when this data needs to be consulted by various people, it must be synchronized with one centralized corporative database. To perform this synchronization it is necessary to develop one application named "Conduit" [6].

The difficulties of this process concern handling the registry's structure of the PDA and deciding on the synchronization logic. In fact, the hardest part of writing a conduit is deciding on the synchronization logic. There are occasions in which records are modified on both sides, PDA and PC, so the conduit has to be able to determine whether changes have been made to the same record in each database, and take an appropriate action. That is not an unusual situation - every application which works with more than one copy of some data, and each copy may be changed without reference to the other, will eventually have to handle that synchronization problem, before merging data back together to form one coherent dataset again.

There are many strategies that can be used. The implemented solution was to maintain the data unaltered on both sides and write a sync log message,

warning the user about which of the records are conflicting and which actions may be performed.

The synchronization logic will also determinate if the project objectives will be reached. Every conduit should achieve the following goals:

- Fast execution;
- Zero data loss;
- No user interaction;
- Conflict resolution.

The technique of uniquely identifying the records was adopted, to conflict resolution, and joined to the "created/dropped/updated" records detection.

To uniquely identify a record, in both PDA and server databases, the following method for primary keys generation was applied:
<USER_ID> + <YEAR> + <MONTH> + <DAY> + <HOUR>+<MINUTE>+<SECOND>+ <MILISECOND>

For example, for the user with ID 4 that inserts a new record at 16:45:35:345h in 16/10/2003, the system will generate the following primary key:

420031016164535345.

In this way, independently of where the record is created, the ID number will be unique and no updates will be necessary when the sync is run.

The "created / dropped / updated" records' detection is performed in the PDA using flags generated by PalmOS, and, in the server database, using logic fields that identify which action was executed on each record. This approach identifies conflicts in the records and optimizes the synchronization process, since only records which experience some action are synchronized.

Having many users also increases the points of consideration when deciding the syncing logic. It might be possible to have changes made by certain users overriding those made by others. To solve this problem, each record has a field that identifies the proprietary user and only him has permission to update or drop that data.

To solve the problem concerned to regional distances between users, the Internet was used through a remote application server that provides access to database server with low cost and security.

2.5. Desktop Client Application

As commented before, PDAs have many limitations that do not permit to run applications which require large-data entries or complex-reports printing.

Face this reality, an application for Windows platform was developed. With this, the user can take advantage of the mobility of the PDA, and of the facilities of the user-friendly interface of the personal computer, where performing better queries, inserting data in a easier form and printing high quality reports is possible.

2.6. System security

One of major requirements of this work concerns the security in database access, due to the confidentiality of information and to the type of access, which is performed through the Internet.

Despite the fact that data is accessed remotely, the access to the DBMS is performed locally, using an intermediate software tier, named application server. The clients establish a connection with the application server and ask for necessary data; the application server establishes a connection with the SGDB and accesses the solicited data, returning to the clients the results.

The SGDB is installed in a computer with Windows 2000 operational system, placed in the Bio-informatics Laboratory of CEFET-PR[1], where only authorized people have access.

The client module for PC has a mechanism to validate user and password, to prevent non-authorized people from accessing the system.

The client module for PDA only accesses the corporative database through the conduit, which answers exclusively the requests of this specific application, using one internally coded user id and password.

As the application server is a DCOM object, any external application can access it, being enough to know the CLSID (Class identifier). Nevertheless, due to the fact that DCOM is an implementation that turns into an operational system component, all security resources of Windows 2000 [8] were used. In this way, there are two users and passwords validations before running the application: the user-transparent ones, that identify if the application is authorized to ask for one connection; and those solicited to user, that verify if this one is authorized to access the application.

3. Results

This tool must be continuously followed, likewise any course that incorporates technology. The team responsible for the program must guarantee the system is operational during all the training. Practical results will only be visible after a training cycle is completed.

The evaluation of PALM-TUTOR is being made according to the concepts presented in [4].

4. Discussions and conclusions

[1] http://bioinfo.cpgei.cefetpr.br

Within the initial objectives, this work contributes to the International Outreach Program of St. Jude Hospital[2], allowing the Brazilian coordinator to disseminate his knowledge on pediatric surgical oncology to physicians specializing in this area and that work in different cities of the country.

Though this work has been developed for a pediatric oncology program, it can be easily extended / modified to other health areas, not only for teaching, but also for use as an electronic handbook.

In the end of the activities of this work, the following conclusions were reached:

Public tools for Palm development presented high versatility. Nevertheless, the lack of database support compromises the development of applications that use large amounts of data.

The data synchronization form between the PDA and a corporative database needs to be friendlier.

Handheld devices are excellent personal organizers, which allow the development of applications similar to the ones for PCs, providing high flexibility and mobility to professionals who work on-site.

The use of PALM-TUTOR eliminated students' rework, in the sense they can register their activities at once. These registers are used for generating the reports requested by the hospital, for activity evaluation and orientation by the coordinator.

The program coordinator had his tasks made easier by the organized registration of students' activities. With the coordinator's orientations also registered, future students may be able to consult them for similar cases, reducing the amount of questioning.

Besides running PALM-TUTOR, the PDA might be used for other medical applications.

Finally, other paths were opened from organized information availability and managed into bases. Despite the fact that the result of this work is an integrating system, some possibilities related to expert knowledge and to data mining can be envisioned – the Brazilian Coordination, besides of being a technological disseminator, will be a knowledge consolidator.

5. References

1. KAUFMAN, D. Developing tutoring skills in Problem-Based Learning. **Workshop presented to faculty at the Catholic University of Paraná**, Curitiba, Mar, 1998.
2. O'NEIL, M. C., WRIGHT A. Problem-Based Learning. **Focus on University Teaching and Learning**, v. 5, n. 2, p. 1-4, Nov./Dec., 1995.
3. OSTWALD, M..J, CHEN, S. E., VARMAN, B., Mc GEORGE, W .D. The application of problem-based learning to distance education. In: **Distance Education for the Twenty-First Century**. 1st ed., Brisbane: ICDE and QUT Press, cap. 4, p. 300-305, 1993.
4. THE JOHNS HOPKINS UNIVERSITY SCHOOL OF HYGIENE AND PUBLIC HEALTH. A Faculty Resource Guide to Distance Learning at the School of Hygiene and Public Health, 1997. http://distance.jhsph.edu/more/DisEdFacGuide.pdf
5. BASS, S. G., Wireless computing: medical students and mobile medicine. **MD Computing**, v. 17, p. 27, 2000.
6. EMBI, P. J. Information at hand: Using handheld computers in medicine. **Cleveland Clinic Journal Of Medicine**, v. 68, n. 10, p. 840, Oct. 2001.
7. HO, W. L., FORMAN, J., KANNRY, J. Portable digital assistant use in a medicine teaching program. **Proceedings of the AMIA Symposium**, Los Angeles, p. 1031, Nov, 4–8, 2000.
8. Rogerson, D. Inside COM, Washington: Microsoft Press, 1996.
9. RHODES, N.; McKEEHAND, J. **Palm™ Programming: The Developer's Guide.** 2nd Ed., Cambridge: O'Reilly & Associates, p. 63-79, 2001.
10. BASS, S. G., Wireless computing: medical students and mobile medicine. **MD Computing**, v. 17, p. 27, 2000.
11. CHESSANOW, N., PDAs for Doctors: Know your needs, pick a device to fit. **Med Economics**, v. 77, p. 81-88, 2000.
12. DUNCAN, R. G., SHABOT, M. M. An enterprise web viewing system for clinical and administrative data. **Proceedings of the AMIA Symposium**, Los Angeles, p. 1169, Nov, 4–8, 2000a.
13. DUNCAN, R. G., SHABOT, M. M. Secure remote access to a clinical data repository using a wireless personal digital assistant (PDA). **Proceedings of the AMIA Symposium**, Los Angeles, p. 210-214, Nov, 4–8, 2000b.
14. EMBI, P. J. Information at hand: Using handheld computers in medicine. **Cleveland Clinic Journal Of Medicine**, v. 68, n. 10, p. 840, Oct. 2001.
15. EBELL, M. H., BARRY, H. C., InfoRetriever: rapid access to evidence-based information on a handheld computer. **MD Computing**, v. 15, p. 289-297, 1998.
16. KOHN, L. T., CORRIGAN, J. M., DONALSON, M. S. To err is human: building a safer health care system. **Institute of Medicine Report**. Washington DC: National Academy Press, Nov, 29, 1999.
17. LAPINSKY, S., MEHTA, S., VARKUL, M., STEWART, T. Qualitative analysis of handheld computers in critical care. **Proceedings of the AMIA Symposium**, Los Angeles, p. 1060, Nov, 4–8, 2000.
18. MCCORMACK, C., JONES, D. **Building a Web-Based Education System.** Wiley, 1997.
19. SHABOT, M. M., LOBUE, M., CHEN, J. Wireless clinical alerts for physiologic, laboratory and medication data. **Proceedings of the AMIA Symposium**, Los Angeles, p. 789-793, Nov, 4–8, 2000.
20. WOFFORD, M. M., SECAN, R., HERMAN, C., MORAN, W. P., WOFFORD, J. L. Clinical documentation: the handheld computer as a survival tool. **MD Computing**, v.15, p. 352-354, 1998.

[2] http://www.stjude.org/newhp/international_outreach.html