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A MODEL FOR INTEGRATING POINTS OF CARE TESTING INTO A DISTRIBUTED HEALTHCARE ENVIRONMENT

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Abstract - **Emerging Internet technologies are applied to create and manage a Virtual Laboratory Information System (VLIS), integrated into a distributed healthcare environment. The main objective of the system is to organise the transference of clinical testing from the traditional large central laboratories to a cooperative scheme of several manageable Points of Care Testing (POCTs). In other words, the goal of this model is to centralise just the relevant clinical data into each Hospital Information System (HIS), instead of concentrating the analyser instruments in outsized and expensive laboratories. The proposed solution is being developed and validated within the DLAB project –an international initiative partially funded by the European Commission– and is described in this paper.**

Keywords - **Point of care testing, decentralisation, integration.**

I. INTRODUCTION

Nowadays clinical testing is essential in health care environments, as an irreplaceable diagnosis tool for countless treatments. The centralised model, successfully applied in the last decades, has turn obsolete. Central laboratories seem to be close to collapse:

a) Healthcare organisations are forced to acquire expensive and complex analysers in order to deal with the large number of patients requiring some kind of analysis;

b) Those devices need to be operated and maintained by a wide high-qualified medical, paramedical and technical staff;

c) Extensive amounts of relationships among patients, staff, analysers and information oblige organisations to implement intricate process models, which can hardly be managed after all in an effective way;

d) Patients may even suffer from large queues of people waiting for their turn, maybe after an annoying travel in order to attend their appointments in the central laboratories.

This situation results in costly laboratories (regarding both material and human resources), inefficiently handled and troublesome for patients, bringing about a deterioration of the quality of service provided by the healthcare organisations.

Recent advances in analysers (miniaturisation, automatic testing procedures, usability, low costs, connectivity...) make feasible to move clinical testing nearer to patients and requiring physicians, significantly reducing the time-to-treatment parameter. Therefore, a convenient Point of Care Testing could be located in almost every healthcare centre or department, and even in patient homes.

In addition, emerging information technologies allow these POCTs to be essentially connected within HIS distributed environments, sharing on-line healthcare data among the different actors involved in patient treatment. At the present time, important efforts are being carried out in this field, e.g. CIC industrial consortium [1], in charge of developing communication standards for seamless connectivity between POCT analysers and HIS.

DLAB is one of the projects focused on this matter. A general architecture for integrating POCT and HIS is offered (see Fig. 1). One of the main contributions of the model is the development of the "Virtual Laboratory" concept, a virtual environment that links through a private network all the POCTs dependent of each healthcare main centre. All together are integrated into a Virtual Laboratory Information System, which is securely connected to the central HIS or even to an Internet gateway.

A singular POCT design is required in order to:

- Make POCT analysers accessible from an information system.
- Organize all the heterogeneous acquired data through a standardized format.
- Allow POCTs to be easy-to-use for non-specialised users.
- Maintain different access levels for avoiding unauthorized manipulation of such sensitive data.

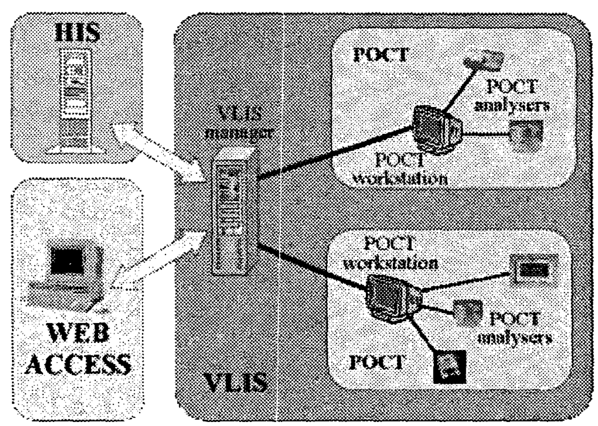

Fig. 1.- DLAB architectural model

At present, the most suitable answer to the previous requirements is to install at least one workstation per POCT, which would handle all the local connections to the analysers and the remote link to VLIS, through a unique efficient, confident and comprehensive User Interface (UI).

II. METHODOLOGY

Each POCT will therefore be composed, as a minimum, of:

- One central workstation.
- An external network link.
- One analyser with a local communication port.

This basic configuration can be seamlessly extended with more analysers and workstations, following the same architecture.

An application will be running in each POCT workstation. Three application layers appear on its functional structure (see Fig. 2):

1) <u>User interface layer</u>: Interaction between POCT and final users will be carefully handled in this module. As they could be non-specialised users, this UI should be as user-friendly as possible, hiding the system complexity in order to reduce learning time and negative responses [2]. For that reason, this layer should be analyser, user and scenario independent. It would support different access permission levels depending on the specific users (requiring physician, nurse, signer doctor, technician, health manager, system administrator, etc.), allowing them to succeed in their respective clinical testing duties.

2) <u>Data management layer</u>: The second module deals with all matters concerning data administration, granting its security, integrity, delivery and other legal aspects. It should handle conveniently potential communication breakdowns.

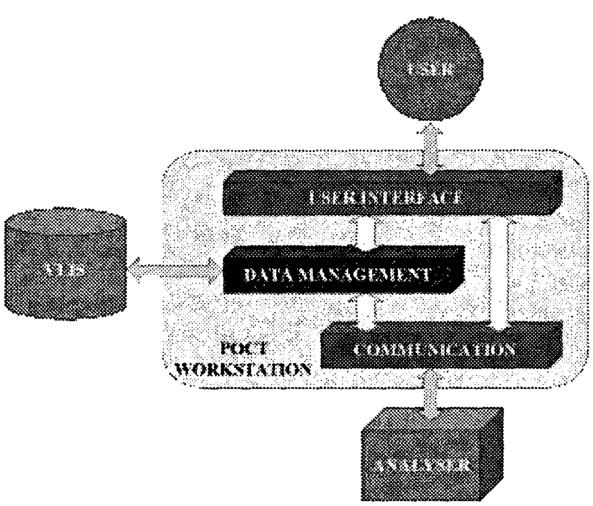

Fig. 2.- POCT functional structure

Some standardisation (data formats, procedures, transmission) should be followed so as to make easier the integration of POCTs into healthcare organisations information systems.

3) <u>Communication layer</u>: The last application layer manages the local interaction between each POCT workstation and its attached analysers. It should show a unique interface to the other modules, translating all the different communication protocols of the clinical devices into a common language [1].

III. RESULTS

The main result of the DLAB project has been the development and validation of a POCT integration model for health care organisations. It has supplied a successful joint between two worlds that used to cohabite but not to interact in an automatic way: laboratories and healthcare information systems. This success has been possible due to two main aspects:

- Firstly, the model is user-oriented, taking into account the lack of personnel with high IT (Information Technologies) knowledge by emulating the manual process that is being currently applied in most laboratories and hospitals.
- Secondly, it has been developed integrating all the involved actors: on one hand, users (medical personnel, nurses, technicians, managers, etc.), and on the other hand, general Information Systems (Organisations, Hospitals, Laboratories...), by means of an open design easy to upgrade.

As explained before, the POCT model has been structured into three different functional levels, depending on the different actors involved in the information transfer.

A. *User Interface Layer*

The first level deals with the interaction with the final users. The main goal of the design has been to obtain a simple and user-oriented system, reducing the time learning curve. Following the user requirements and the exact scenarios where the POCT is going to be used [3], a convenient UI has been developed with several special features. Starting from a typical laboratory environment and its common daily activities, a software application has been implemented, following an open pattern that mainly suits any POCT scenario. Besides, the UI has taken into account that sensitive medical data, subject to severe confidentiality laws, is being handled within the system, providing different access permission levels for each kind of user and other security features so as to prevent unwelcome data manipulation or display.

Finally, this UI tries to emulate, as an implementation metaphor, the real process currently followed on laboratories, which is manually done until now, aiming to make easier the respective tasks of the medical personnel:

- Give the user the control of the process.
- Maintain the user always informed about the available possibilities, showing always where he is, where he is going and where he has gone.
- Reduce the memory load.
- Preserve the coherence of the screen elements in order to maintain a homogeneous view all throughout the steps.

B. Data Management Layer

The data management layer acts as a transparent module for users, gathering and supplying all the relevant information within the POCT. This level organises the data transfer among the POCT modules and the rest of the information system. The user requirements asked for a reliable module where data were safely delivered despite of communication problems such as network disconnection. To fulfil such premises, a group of data and communication tools has been incorporated together so as all the incoming information (from UI, analysers and VLIS) is stored in a local database, assuring a reliable transmission and automatic integration of all the databases within the system.

This layer is composed, first of all, by a local MS-SQL database that is a light copy of the tables and relations of the VLIS database, in charge of dealing with the processes that are taking place in the POCT environment. This database allows the application to store all the information used and received to grant the correct updating of the whole system. After this information is securely locally stored, this module proceeds to transmit it to the rest of the D-LAB components. To do so, it automatically generates a delivering message, by extracting the relevant data, which is stored into a message queue from the Microsoft Message Queuing (MSMQ) service. The use of this tool grants the reliability of the communication, the security of the transmission and the possibility to know the status of the transfer at any moment. MSMQ has his own MS-SQL database to store the sent or received messages until they are correctly processed, keeping in memory all the pending tasks even if the network breaks down. This link is automatically resumed whenever possible.

It is worth to remark the openness of this layer due to the use of XML format for the data messages. This standard is becoming the future of communications within the Internet, allowing data to be understood through almost every data environment, such as SQL or Oracle, using any programming language. Messages become a dynamic piece of information easily converted between formats by the use of XSL.

C. Communication Layer

The last module includes all the drivers that manage the local interface with the POCT analysers. The different communication protocols are embedded and translated into a unique interface in order to perform the information exchange with each device in a standardised manner. This kind of middleware is in charge of ensuring compatibility and independency for the other POCT modules, allowing not making difference among devices.

IV. Discussion & Conclusion

A model for integrating POCTs into a distributed healthcare environment has been presented within this paper. This 3-layer model is now being technical and clinically validated in Athens Medical Centre hospital (Greece) and AUSL Modena (Italy) through different use scenarios and POCT devices (RapidLAB 800 from Bayer, Advia 60 from Bayer and ABL700 from Radiometer). These validation results shall be available in further months [4].

Decentralised laboratories come to be in the near future the most cost-effective solution in the clinical testing field. This POCT distribution model contributes to a gradual evolution for healthcare organisations from the current situation to the imminent one. The integration of all the oncoming information in a Virtual Laboratory Information System through intrinsic standardisation (processes, procedures, data formats, communication links...) provides a reliable and efficient solution at very reasonable installation and support expenses.

Nevertheless, what remains clear is that any model oriented to the adoption of emerging technologies in the healthcare sector will only succeed whether all the actors involved in every care process assume their new roles, even for well-structured high quality models.

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