An Informative System for Chronic Heart Failure Patients Follow-Up (CHeF)

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Abstract

To face the challenge of chronic heart failure diagnostic work-up, an informative system (CHeF) has been developed, which allows data collection from ambulatory and/or inward patients in order to improve individual care and to establish a database for prospective/retrospective analyses.

A scalable structure has been adopted to let the system running in different environments (from stand-alone systems to strictly integrated with outer system).

The CHeF core system was designed as a meta-definition database, in order to follow frequently updated parameters tracking and to fit physicians research results. This structure characterized by a dynamic interface developed in Java language, permits rapid changes in structure and functionality.

1. Introduction

Chronic heart failure (CHF) is a most difficult challenge for either the cardiologist or generalist, due to the increasing number of patients surviving an acute cardiac event evolving towards chronic illness [1]. CHF is a complex syndrome, requiring frequent diagnostic assessment of multiorgan function (not only heart and vessels but also kidney, lungs, liver, etc.), and collection of individual information on treatment and outcome.

The huge amount of data must be summarized, permitting to draw easily the time course of symptoms, physical and objective descriptors of patient status. To achieve this goal, an informative system (Chronic Heart Failure, CHeF) has been developed in the Institute of Clinical Physiology for collecting data during in/outpatient examinations and to extract features of interest from history, physical examination, humoral sampling, noninvasive diagnostic procedures (such as EKGs, cardio-pulmonary stress tests, ambulatory EKG recordings, chest X-ray examinations, Echo Doppler studies, nuclear medicine procedures, catheterization) and on treatment, follow-up, hospitalization and invasive or surgical procedures, cardiac events, such as life-threatening arrhythmias, infarction, or death).

2. System structure

The system is based on a relational database containing clinical and administrative information and is integrated with an Hospital Information System (HIS), where it has the role of a *functional island* as a data generator [2].

The synthetic CHeF diagram is depicted in Figure 1.

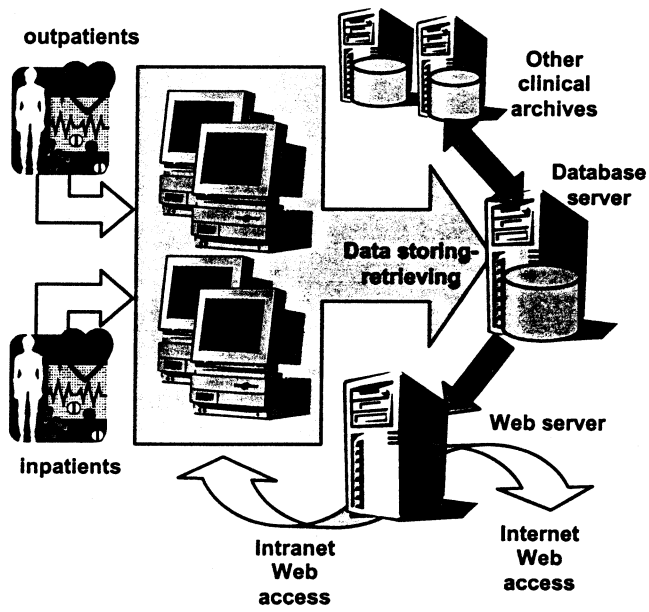

Figure 1. Structure of CHeF Information System

This scalable system starts from a basic configuration consisting in a workstation populating a database

contained on the computer itself, up to the last step in which the database is housed on a server, common to other workstations, where data are strictly linked to other external systems, such as hospital information systems.

The basic configuration, shown in Figure 2, uses as a local database any system capable to use JDBC layer 3-4 or ODBC driver (more frequently Microsoft Access on MS-Windows and postgreSQL under Linux) [3]. This configuration is used when network support does not exist or does not fit requirements of velocity and safety, because patients data must be always available, thus ISP connection have to be secure, else should be avoided. The same configuration is also used where data flow level does not reach a minimum level of cost/effectiveness as concerns equipment and investments. All text reports are generated locally, allowing documents generation and retrospective analyses for administrative purposes.

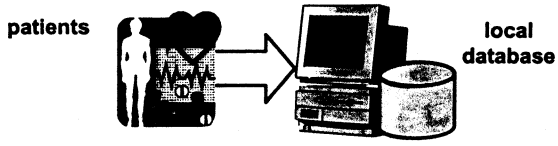

Figure 2. Local configuration.

Locally collected data may be exported, within a defined time scheduling policy or data amount driven policy, to a central archive, common to a set of local workstations, in order to achieve the same goal obtained with the full network configuration described above, satisfying research purposes. The protocol used for data extraction is the HL7 one, also embedded in a document definition table of XML protocol, thus gaining a large scale of compatibility with other external archives interested by data collection. Data are finally delivered to a server resident modules where information is decrypted and stored, decoding HL7 protocol.

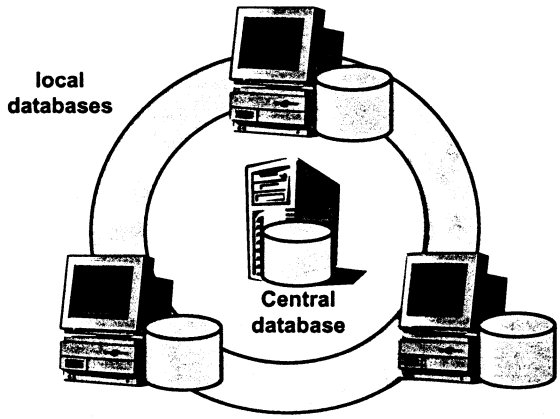

Figure 3. Central data gathering.

The third step is an extension of the basic configuration, by the use of a central database server housing all data concerning CHeF structure, instead of local databases. The database server actually is an IBM-DB2 version UDB5.2, maintained on an AIX operating system.

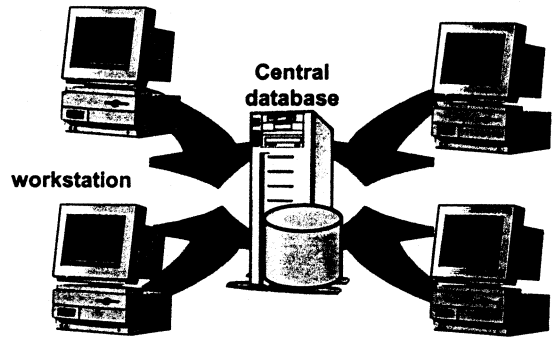

Figure 4. Central data storing configuration.

This database contains administrative-related, demographics, admission and discharge data, different from CHeF specific informative content, sharing information common to system workstations collecting clinical data.

The last step is shown in Figure 1, consisting in a strict integration of the database server with an external HIS and a WEB server (to allow external consultations) and with other archives representing data source for booking, examinations data or features, administrative data, etc. In order to insulate the working area from external undesired access, a firewall is established limiting database access and WEB consulting only from authorized workstations.

2.1. Database

This system has an open architecture and its core subsystem, called "Matrix", represents a platform for successive integration and development in a long-term initiative. Data collected are stored in a meta-data definition tables, where each feature is recorded as an independent data definition, in terms of:

- data description and assigned name, as unique identifier
- data type (string, integer, decimal or boolean value, etc.)
- data length for string definitions, or range for numeric definitions
- list of possible values, even brokered by a trans-codification layer, with individuation of a common default value
- graphical component to display in user interface
- tips and help text, displayed during the use of the system

- data input policy, optional or illegal data missing
- control fields and data source

To define a minimal, fixed data-set, a certain experience should be provided, coming either from physicians visits or diagnostic procedures.

During CHeF development, the definition of a single collected feature followed a bottom-up approach, where common clinical data were first inserted (administrative and identification data), before other advanced, user-selected features (e.g.: NYHA class, measures, others). Relevant information to be collected could be changed/added in a meanwhile, to adjust and realise a data-collection paradigm: "large dataset secures massive and exhaustive quantity of information, but such a complex and large data set is difficult to maintain in the long run and creates resistance against the system"[4]. From an initial minimal data-set a feature enhancement followed a short-term experimentation pathway, that led to larger and more consistent data definitions.

In our system design an IBM-DB2 Database was used, but any other DBMS could be used instead of this, it is sufficient that DBMS supports JDBC layer4 in order to maintain multiplatform capabilities.

2.2. Data connection

The whole system is considered as a functional unit integrated in a large Hospital Information System, from which inherits patient identification information and clinical history, besides many other parameters collected in different subsystems, by automatic retrieval of those mapped clinical data.

From CHeF point of view, HIS contributes to increase information collected in the daily clinical routine, merged in an overall electronic medical record, because integration with HIS enhances basic data with novel annotations and examinations results, coming from ward nurses and physicians. This amount of information is used only for automatic extraction of features or data, already defined in CHeF.

The Matrix core system has been designed for a direct integration with other systems where the same type of data definitions are present, thus CHeF, being a Matrix customization, inherit this important feature. Those data, extracted from other systems, are called "source data" and can be retrieved automatically from CHeF, or regenerated by a manual command in case of local data corruption or typing errors.

The Use of HL7 protocol embedded in XML, combined with terminology standards where applicable, promotes standardization, while facilitating efficient search of stored records.

3. CHeF User interface

With the widespread of computers in daily activity, both in hospitals and in research environments, one of the most common requirement for new software or systems is its capability to run on different machines and under different operating systems.

In order to comply with these specifications our system was developed in Java language, which guarantees a free integration on many popular operating systems and platforms and allows, through the JDBC protocol, an easy integration with many different database systems.

3.1. Client application

A graphical user interface allows an easy navigation of patient data like etiology, drug administration, different parameters graph tracing. Besides formatted data presentation and graphic data display, the main interface allows the manual input or editing, in case of missing or incorrect data.

Two different types of graphical front-end have been developed for users, and both interfaces are based upon the same data structure. The first interface has been developed using classical components, and follows optimal ergonomic standards; an example of such interface is shown in Figure 5.

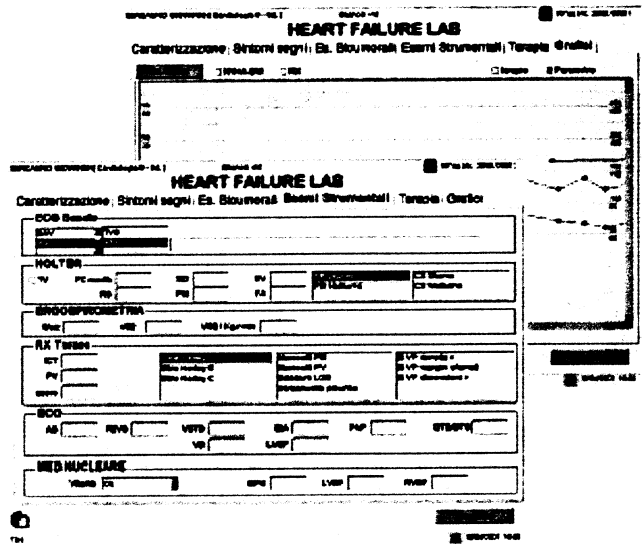

Figure 5. CHeF typical interface. Synthetic data are shown as measures or trends

Another interface typology is provided, which does not require any specific programming, by the use of a component dynamic instance, assigned in data definition. This interface follows immediately data-set changes, due to its data-component definition, and thus called "dynamic interface". The same functions are available in both interfaces: patient data chart zooming and synthesis

of physical examinations, history, medications and symptoms on one easy to read graph.

The system define a pathway to follow in data collecting: from the initial step of patient selection and visit, to a second step where data are grouped in subsets of clinical-related paragraphs, concerning current examinations, current parameters measures, signs and symptoms evaluation, past examinations and patient history. Some safety systems ensure data quality, such as exact patient/visit individuation, specific dictionary verification for all structured data insertions/changes, or range matching for numeric parameters. This validation is aimed not only to assure the quality of data collected, but avoid major oversights, secondary to inappropriate data collection procedures.

Finally, the system generates an HTML based printout, for the patient or general practitioner, containing visit results and therapy prescription. For minor implementation of this system, where interaction with other systems is not required, a complete module substitutes data interaction with external administrative system, and printouts are generated locally instead of being WEB based.

3.2. Web

As concerns the latest CHeF configuration, where a WEB secure server is established in the system structure, a WEB module represents the front-end for remote data-retrieving extension, allowing a rapid consultation of synthetic data for each patient, respecting security and confidentiality.

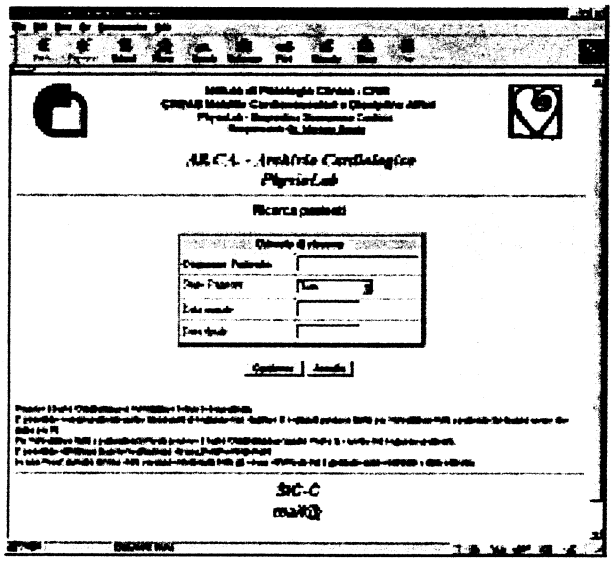

Figure 6. CHeF WEB interface: patient selection.

The system is based on dynamically generated HTML pages, using a Java servlet engine, namely Tomcat-Jakarta or e-Planet, which is connected to the CHeF database through the same typology of JDBC channel used in client application. Generated pages include patient history, graphical representation of parameters trend, and include documentation and reports, which might be printed as a part of a paper-based medical record.

An adequate level of security, due to data privacy and legal bindings, is reached through an SSL connection and minimizing local data caching for locally generated HTML pages (deleted anyway, after visualization once browser is closed).

4. Conclusions

The system developed allows scalable configuration in Hardware support and in data collection definitions.

The defined database permits not only to optimize medical diagnosis and treatment in the CHF patients, but also to evaluate the prognostic impact and cost/effectiveness of diagnostic procedures or therapeutic interventions in homogenous subsets of patients (for etiology, clinical status, treatment, etc.).

The integration of CHeF with different data sources is essential to the achievement of completeness of information for each subject registered.

Easy data input and consultation, obtained by data section subdivision, consumptive graph and typing aids avoiding logical input mistakes.

References

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