

From Passive to Active in the Design of External Radiotherapy Database at Oncology Institute "Prof. Dr. Ion Chiricuță" from Cluj-Napoca

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Abstract: Implementation during 1997 of a computer network at Oncology Institute "Prof. Dr. Ion Chiricuță" from Cluj-Napoca (OICN) opens the era of patient electronic file where the presented database is included. The database developed before 2000, used till December 2006 in all reports of OICN has collected data from primary documents as radiotherapy files. Present level of the computer network permits to change the sense of data from computer to primary document. Now the primary document is built firstly electronically inside the computer, and secondly, after validation is printed as a known document. The paper discusses the issues concerning safety, functionality and access derived.

Keywords: Database Management Systems, Radiotherapy.

Introduction

The universal problem in any informatics system is to assure correct database collection in fastest mode possible [1, 2, 3, 4]. This is the basis for a support decision in a modern management [4]. Natural solution, with no change of the functional-administrative structures supposes to take into the computer the data from primary documents [1]. When the data arrive in computer usually, errors are revealed but they cannot be correct due to the natural delay from the creation of document. Therefore the manager objective is to have no erroneous data by shortening the time between real data and data inside a computer [1, 4]. Powerful software and a special training of the user have limited effect [4, 5]. Our proposed optimal solution is to design software by which primary users are producing the documents firstly inside the computers, to validate and eventually to produce a printed version of them.

Use of computers in radiotherapy has a mature age starting with the systems to compute the irradiation times [6] in the years 60-70. Starting from here the training in the new system was relatively simple with no trouble.

General Scheme of Database Functionality

Resulted information from the treatment of patients by irradiation is comprise inside the **irradiation file** and for now is illegally to omit the printed or handwritten version [7]. The information stems from the medico-administrative activities. The list of these activities in a semi

chronologic order is: **prescription**, **irradiation** and **administration**. Below is a brief description of them pointing out essential elements concerning the functionality of the database.

Prescription is in the exclusive use of physician [1, 2, 4, 7]. The database does not contain clues, which has conducted to the elaboration of prescription. In other words prescription is interesting only as the start point of all activities linked to treatment. With this in mind the prescription [6, 8] must contain irradiation fields and the treatment details with no interest in justify it. The core of the prescription is the main object of another database which must be integrated in the electronic file of the patient and the presented database.

Next step after the validation of prescription is **simulation**. If the prescription contains only general terms, during the simulation the fields of irradiation are settled to values resulted from the real process of simulation. All clues linked to the fields of irradiation are generated inside the computer by the executive staff assigned.

In **physicists' department** all calculus for each field of irradiation are achieved [6, 9-17]. The whole activity here is based on the clues coming from simulation. The physicist verifies the whole registration previous to his work. Each field is validated individually by the physicist after retying of final result. The computer suggests his own result on the screen but that must be validated by physicist. Validation of this step is the sole option to start the timetable of treatment by irradiation.

Daily irradiation is possible only in the case when all previous activities from simulation a physicists are validated. All fraction of irradiation are noted in the database. When prescribed dose is reached special warning messages are displayed.

Administrative actions are involved in the whole process. This can be seen firstly with the action of secretaries which are producing scheduled reports for manager or other departments.

From the all departments from the above we are grabbing pieces or fragments of data exactly as in real world. These fragments have three states: **edition**, **validation** or **deleted**. Supplementary each fragment of data including present or past can interact and can restrict the occurrence of other fragments of data.

In edition is any entity, which contains usually many pieces of data, at the moment when is generated. In this state the accepted users can modify any data of this entity. During the process of edition many warning messages can be displayed guiding the user to a correct filling of the data. Validation state is the state produced by the user to announce the computer that a entity is correctly filled and he or she does not want any more modifications. Of course the transition from edition to validation cannot be fulfilled only after a final check of the computer for the supposed errors. After validation, the user is forbidden to modify that entity. If the data contained in the entity has no more use due to justified objective reasons, a matched user can erase this entity but there is not a physical erase, is only a cancellation and the data can be displayed but with a special mark: an X in red colour in the texture of data. Therefore the user cannot modify any piece of data marked in this way. None can change an entity from the erased state. The entity remains for ever in this state. If special reasons ask and entity with identical values it can be made a copy and the whole process is restarted from the edition. For full safety and to increase users responsibilities, automatically all changes of the entities states save data an hour of transition and all data which identify the user.

To see easier the state of edition we use the sign « in the texture of the entities to denote the state of edition.

Concerning the treatment, a patient could be **in treatment** or with the **achieved treatment**. Corresponding to the real world these data are reflected in **Irradiation record** which has same two states. When the **Irradiation record** has the state of **accomplished treatment** then none can modify it. On the administrative facet the act of sealing the **Irradiation record** is accomplished at the **Secretary Department** where also it is checked the quality of treatment and accuracy of data which are registered in the database. It is natural the requirement that this state to be the last one. If there are special technical conditions or evolution of the patient, the **Secretary Department** can “reopen” **Irradiation record** that is a come back to the in treatment state. The principle of no lose this event must be preserved. This time the notification is made from beginning, on the first page of the entity containing data of the patient. After all at the reopen the database requires the motivation which will be displayed in the future when someone consults his data.

Below it is presented on short the main working points with theirs actions.

Simulator

It is the first place where identification data and fields of irradiation of the patients are registered. Figure 1 contains a template during the grabbing of data for an imaginary patient.

The screenshot shows a software interface for patient registration. On the left, there is a form with fields for personal information (Name, Surname, Sex, Date of Birth, Address, etc.) and treatment details (Treatment Type, Location, etc.). Below the form are buttons for 'New field', 'Dupl. field', 'Change', and 'Delete field'. On the right, there is a vertical stack of buttons and status indicators:

- New record**: Initiates a new patient record.
- Modify pt. data**: Allows modification of patient data.
- Change pt.photo**: Changes the patient's photo.
- Change activity**: Changes the activity status.
- Validat pt. data**: Validates patient data.
- Release record**: Releases the record.
- Actual pt. Personale**: Shows the current status of the patient record.
- Record Status**: Shows the status of the record (e.g., treatment achieved).
- Edition 1**, **Valid 0**, **Delete 1**: Statistics for the current edition.
- New search**, **Refresh search**: Search functions.
- New search validated**, **New rqst. validated**: Validation search functions.
- Lipsa NID**, **CasaDeAsigurare nu este in lista!**, **Lipsa Data_Nasterii**, **Observati**: Error messages.

Figure 1. Simulator

Let's see first some safer elements which are present at all records. They are placed on the right of the screen.

First element is data and hour and who has created this entity. On figure one can see when personal data of patient has been settled by the operator: Mateas Diana at 13:08 on 27/6/2007.

The second element is data and hour when validation for patient personal data is accomplished. At the moment from figure 1 the validation is forbidden due to errors present.

The errors are shown on the right down side of the screen in red colour in a frame labelled "Errors". Also the registration is marked for edition (present).

When the operator solves all errors he or she can press the button **Validate patient data** to change from edition to validation.

Name, family name, title and other administrative clues are displayed continuously during all the activities. As previous same date including data and hour when they did deletion or accomplishment of the case are presented.

Another clue displayed all the time is the present state of the registration and a short list with history if there are some. Of course for a patient excepting the number of deleted registrations there is only two possible versions: 1) one registration in edition and none validated or 2) one registration validated and none in edition.

On the right of the screen there is an administrative zone which contains date and hour of server and some buttons with special functions.

First button **New record** start a new registration for a patient. Patients are identified with a unique number of identification (NID) as they arrive for the first time in our clinic. For accuracy all printed documents of a patient have this number coded with bar codes.

The second button **Modify patients data** pressed when we are on a validated registration induce the changing of the status from validated to deleted. Graphically the symbol is changed from to an X red in the texture of registration which is the symbol associated with the deleted registrations. In the second phase a duplicate of the registration is made and the duplicate is set in the edition status. In this way the operator can modify this copy and finally can validate it. The numbers of registrations in edition, validated or deleted are modified accordingly.

The third button **Change the patient photo** is completely understood by itself. To increase the treatment safety it was adopted for each patient to memorize the photo of his face and his tattooed

fields. This button is implied only for the face of the patients. The photo of the face of patient is located on the centre of the screen and is shaded on figure 1 to preserve the patient confidentiality. Due to supplementary times needed to manage the photos the administrative decision was to postpone the use of photos.

The button **Validate patient data** is explained by itself. When pressed all data of patient are checked and if the checked succeed the registration is set on the validate state. Graphically this is made by erasing the symbol from the texture of data. Practically when a new case arrive the barcode of the NID is read and from another database personal data of the patient are loaded. The operator has to load his specific data and validate.

By the **Change activity** button the operator can execute other assigned functions depending of his competency. There are many competency associated to the functional role they have inside the whole system: medical doctor, nurse with different competency, physicist, technical personnel, etc.

Buttons located below on the right side **New search**, **New request**, **Modify last search** are used to identify the record or records of interest at fixed moment of time. The variants **New search validated** and **New request validated** have same function as the precedent but the research is constraint only for validated records.

The access of database is concurrent but when an user gained the access for modify of a record this record is blocked for modify to the other users. The computer cannot decide automatically when to release a record. The button **Release the record** when is pressed produce a release of the record as it can be modified by other user. For a user, the common action is to fill the information and when he or she has finished they must press **Release the record** so that another user can use it.

The screenshot displays a complex medical software interface. On the left, a main window shows patient details (Dr. GRECEA DANA, Rez. _____, Nr.Fisa 200701409) and a list of fields (No.fields 2, Edition 2, Valid 0, Delete 0). It includes a red circular icon with a question mark and the text 'Missing Physicist irradiation time'. Below this are various input fields for treatment parameters like Aparat Primus, Energie, Mod_Calcul, and Dimensiune X. On the right, a vertical stack of windows provides administrative functions: 'New record' (with dropdowns for ID and date), 'Modify pt. data' (with dropdowns for name, function, and title), 'Release record' (highlighted in yellow), 'Create' (with details for Maleas Diana), 'Validate' (with details for Maleas Diana), 'Actual' (with details for Timis Sinzaiana), 'Stare' (with 'treatment' and 'achieved' checkboxes), and several buttons for 'New search', 'Refresh search', 'New search validated', and 'New rqt. validated'. At the bottom, there are 'Observations' and 'Errors' sections.

Figure 2. Simulator, irradiation fields

Buttons below on the left side are working on the irradiation fields. Figure 2 is a hypothetical continuation for a patient partial presented on figure 1.

At the moment of figure 2 there are 2 fields of irradiation with the status: Edition 2; Valid 0 and Delete 0. On the sub screen of figure 2 it is displayed the field number 1. Inside this sub screen it can be seen data and name of operator for each transition that is for **Creation**, **Validation** or **Deletion**. Of course in the texture there is the symbol and X for **Edition** and **Deletion**. If there is no such symbol it is understood **Validation**. In the centre, in red, in the area of errors there is a warning that the physicist irradiation time is missing.

The buttons from below on the left side contains natural functions as **New field** to create a new field, **Duplicate field** to duplicate an existing field and then to adapt it to concrete use, **Change photo** to adapt the photo of the field to reality and **Delete field** for deletion of the field with the

mention that it is only a logical deletion that is the field exists in the database but in its texture there is an X and none can modify it.

The team from simulator (medical doctors, nurses and manipulators) fills the fields with all data, the validation of that is made only by the physicist after complete achievement of calculus of irradiation time or monitor units.

Physicist Department

Data used here are structured on two levels depending of the competences of physicist: one common competence for all physicists of department and one linked to dosimetry and characteristics of devices. Common competence adds same data as from Simulator and supplementary information concerning how they compute the irradiation times or monitor units (below on the half side of the sub screen in figure 3). Photo of the field is missing because in this phase we do not need of it.

The screenshot shows a software interface for treatment planning. At the top, patient information is displayed: Dr. GHILEZAN NICOLAE, Rez. Popescu Aura, NID [REDACTED], Aparat Primus, As. [REDACTED]. The date is 16-07-2007, and the time is 18:13:00. Edition 0 is selected. Buttons for 'New search' and 'Refresh search' are visible. Below this, a search bar is shown with 'Search' and 'treatment achieved' buttons. To the right, a list of treatment types is displayed:

- 1. Calcul timp/MU ICRU 50
- 2. 2D Secțiune raza centrală
- 3. 3D Conformal
- 4. 3D
- 5. 2D Secțiuni multiple
- 6. Sumare planuri 3D conformal

The main workspace contains a form for defining treatment parameters. It includes fields for Aparat (Primus), Energie (Fotonii 15 MV), Mod_Calc (Izocentric), Mod_Tratament (Stationar), Supr.Prot., Echiv., and Filtre. A red gear icon is overlaid on the interface. Other fields include Doza_Prescrisa (22.5), DT_Ef., Prot. (Da), Pers. (Nu), Gantry 0, Colimator 0, DSP 87.8, Dimensiune X (15.27), Y (8), and Doza_per_fr (0.9). A section labeled 'Irradiation times' lists 13 values from 1) to 13). Buttons at the bottom include 'Valid field', 'Compute time or MU', 'New field', 'Terminate field', 'Dupl. field', 'Mod.Treatment', 'Dupl.&Del field', 'Delete field', 'Eliminate field', 'Print fields', 'Refresh search', 'Copy fields parameters', 'New search validated', and 'New rqst. validated'.

Figure 3. Physicists department

We are going over **New search**, **New request**, **Modify last search**, **New search validated**, **New request validate**, **Change activity**, **Release the record** buttons because they have same signification as before.

The action of **Compute time or MU** button on a valid field produces the filling of field labelled with **Computed**, depicted in blue, with the value furnished by computer with the algorithms from cited papers [9-17]. At this time to achieve the action of the physicist, he or she has to complete the field labelled with **Physicist**. Anyway in the field labelled with **Final** is taken the value from the field labelled with **Physicist**. So the value furnished by computer must be validated by the physicist by typing. A safety common practice of the physicist is to compute the value of times to irradiation or monitor units with a second system. This freedom can be used in the situation when unpredicted modifying of the parameters of the devices must be implemented very fast and a normal procedure

is longer. To help these special procedures the button **Copy fields' parameters** passes the field's parameters in clipboard with the intention to be used in an ancillary system.

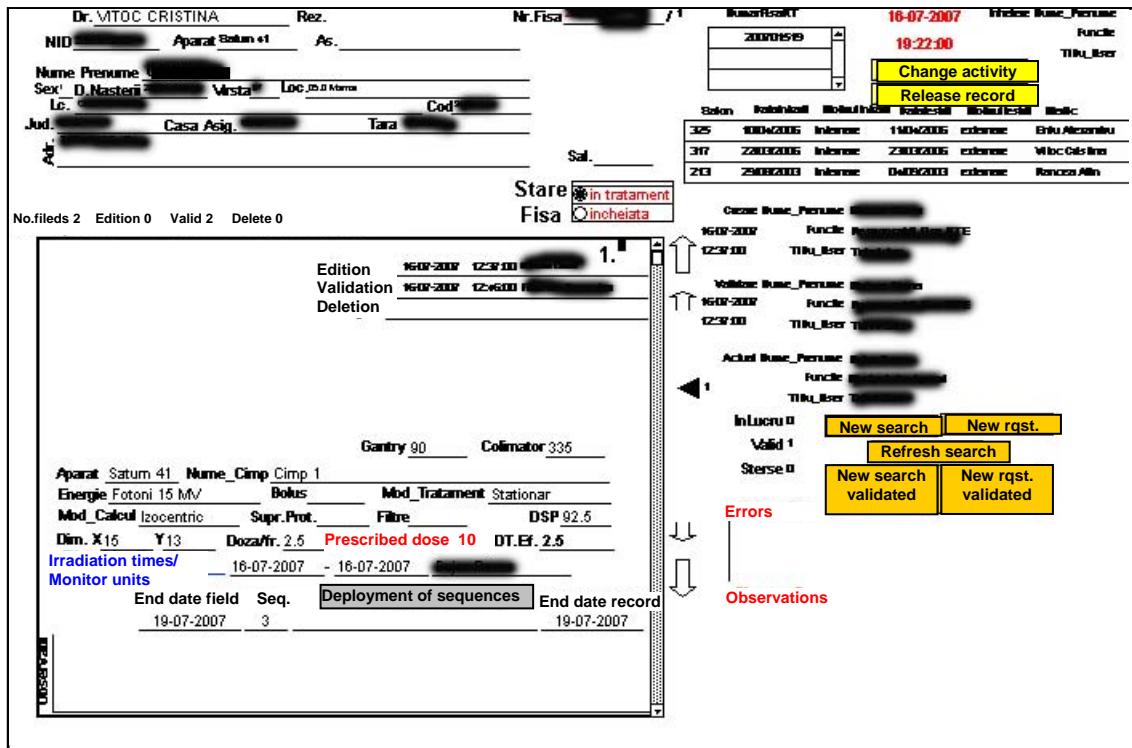


Figure 4. Manipulator – patient identification

After the completion of irradiation times or monitor units and other physicist details concerning the treatment plan, the physicist can press the button labeled with **Validate field**. The immediately graphic effect is to vanish of the symbol for edition and the staff from the irradiation devices can process the next steps of the treatment as it can be seen below.

Before the presentation of details of treatment we due to present the button **Print fields** which produces a legal document including all details of computing and which is attached to the whole medical records of the patients. The physicist can do any operation from **Simulator**. Of course this procedure is not the natural way and deeper in the database the identity of the person which executed this procedures, data and hour are denoted.

Another group of actions at the hand of physicist are under the buttons labeled with **Terminate field**, **Modify Treatment**, **Eliminate field**. **Terminate field** permits to interrupt any future action on these fields. In the texture appears the letter T to mark this status. **Modify Treatment** produces the change from validate to **Modify Treatment** with an MT in the texture. In future this record cannot be modified and a copy of this record with the status edition is produced. The physicist can modify this copy, can validate it and a new irradiation can start for this field. **Eliminate field** is another variant which eliminate the field with no future traces but the condition is that the field has no parts validated. If the field has any parts of the system validated the action of this button has no effect.

Special competence of some physicists is accomplished by the buttons: **Modify Devices-Energies** and **Settlement of constants** for technological parameters and **Modify TMR, PDD, PSF, FIT** for dosimetry as indicated in the papers [7, 9-17].

Irradiation Department

After the validation of all fields in the department of physics the main screen, which direct the activities in the department of irradiation is depicted in figure 4. The image is comparable with the image from simulator but supplementary there is **Prescribed dose** and **Effective dose** and some specific functionality for this team.

The start of the activity consists from an identification of the patient by using of the function from the buttons **Refresh the search**, **New search** or **New request** or combinations. The second step is to identify the field where the patients have to continue the irradiation. The operator, manipulator in this case, can choose the field by acting the arrows on the right side down an up. When fixed the field, the operator acts the button **Deployment of sequences** to see/ and/ modify a new sequence.

The figure 5 presents a possible deployment of events. Upper side contains information about the level touched in treatment of patient. In the texture of each sequence of treatment this time can appear same symbols concerning the status of the sequence (edition, validation and deletion). Only one sequence of treatment can be in edition and correlations with other databases inside the OICN are verified. For example is forbidden to complete a sequence for a hospitalized patient if he or she has no data of hospitalization for that period. The main algorithm is to generate a sequence of treatment, complete it and validate it. Buttons on the right side below are generating diverse sample of sequence which can be modified and validate later. Each sequence on the right side contains a zone where the errors are displayed.

<p>Dr. VITOC CRISTINA Rez. Nr.Fisa [REDACTED] / 1 16-07-2007 Înheiere Nume_Prenume NID [REDACTED] Aparat Saturn 41 As. _____ Nume_Prenume [REDACTED] Sex_f_ D.Nasterii [REDACTED] Vîrstă [REDACTED] Loc. 05.0 Maramă Lc. [REDACTED] Cod. [REDACTED] Jud. [REDACTED] Casa Asig. [REDACTED] Tara [REDACTED] Adr. [REDACTED] Sal. _____</p>	<p>19:43:00 Funcție Titlu_User</p> <p>Release record</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Salon</th> <th>DataIntrari MotivulIntrarii</th> <th>DataIesiri MotivulIesiri</th> </tr> </thead> <tbody> <tr> <td>325</td> <td>16072007 intemare</td> <td>16072007 exedmare</td> </tr> <tr> <td>317</td> <td>20072007 intemare</td> <td>20072007 exedmare</td> </tr> <tr> <td>213</td> <td>20072007 intemare</td> <td>20072007 exedmare</td> </tr> </tbody> </table> <p>Create Nume_Prenume Mat. urmărirea [REDACTED] 16-07-2007 Fundie Rez. [REDACTED] Titlu_User [REDACTED]</p> <p>Validate Nume_Prenume Mat. urmărirea [REDACTED] 16-07-2007 Fundie Rez. [REDACTED] Titlu_User [REDACTED]</p> <p>Actual Nume_Prenume Baza de date [REDACTED] Funcție [REDACTED] Titlu_User [REDACTED]</p> <p>Edition 0 Validation 1 Deletion 0</p> <p>Errors</p>	Salon	DataIntrari MotivulIntrarii	DataIesiri MotivulIesiri	325	16072007 intemare	16072007 exedmare	317	20072007 intemare	20072007 exedmare	213	20072007 intemare	20072007 exedmare		
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317	20072007 intemare	20072007 exedmare													
213	20072007 intemare	20072007 exedmare													
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Rec. Date Dose Numberers of fields <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td>1.</td> <td>16-07-2007</td> <td>2.5</td> <td>Sp. de zi</td> <td>Bolz_Rates</td> <td>1607-2007</td> <td>12:17:00</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>Bolz_Rates</td> <td>1607-2007</td> <td>12:17:00</td> </tr> </table> <p>New sequence Validate seq. Del. sequence Hosp. Interclinic. Outpatient</p>		1.	16-07-2007	2.5	Sp. de zi	Bolz_Rates	1607-2007	12:17:00					Bolz_Rates	1607-2007	12:17:00
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				Bolz_Rates	1607-2007	12:17:00									

Figure 5. Manipulator – sequences of treatment

Reports

Secretary of the general staff of the treatment service supervise the whole activity. The database is a powerful device that can be used by the manager to build his politics. Therefore special program verify all correlations with other database on the hospital and special reports are produced.

At each meeting of the general staff a report concerning the failures, charges of the devices and staff, a summary with new plans of treatment which are the final results of the database, are produced.

Monthly special economics reports are produced for chief accountant.

Functions concerning the archive of the records with achieved treatment are also implemented.

Discussion

The main idea of the system presented here was born in the middle of the year 2006 as a reaction of the staff facing the difficult reports and index of functionality asked by the administrative system.

Because the majority of databases in OICN are build under Filemaker [18] the new system was developed under this software. Since 1 January 2007 all patients with prescription of external radiotherapy was reported under this new software.

The system takes online all data and the responsibilities are exactly assigned as in ISO Model [19]. The quality of administrative data has been improved considerably.

Treatments safety [19, 20, 21, 22] was increased by automatic strict check of total dose and by blocking the records when necessary.

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