
Can We Trust Open Source Software in Intensive Care

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Electronic Health Record: advantages

- precision,
- coherence,
- readability,
- presentation of data
(simple)

Bradbury A, Computerized medical records: the need for a standard, *J. Am. Rec. Assoc.* 19(3) (1990), 25-37

Information technology must allow

- To enhance the quality of information
- The accurate and fast transmission of information
- To encounter specific needs
- To access patient's data where and when it is needed.
- To better treat the patient.

Collins B, Wagner M, *Int. J. Med. Inf.* 74(11-12) (2005), 917-925.

Elliot B, *Del. Med. J.* 74(11) (2002), 435-441.

System powered by a database

- The data can be stored efficiently
 - Past data can be retrieved by queries
 - And the results combined to be analysed
 - That can facilitate audit and retrospective (and prospective) studies.
-

These advantages are also expected in Intensive Care where we find

- High quantity of data
 - High Turnover
 - Need for safety
 - Necessity of analysis and audit processes
-

Choice of the information system

- > Commercial PDMS for Intensive Care with locking in proprietary software
- > Use of Open Source Components and Software (OSS)

Carnall D. Medical software's free future. *BMJ* 2000; 321: 976.

Peter M. Yellowlees, Shayna L. Marks, Michael Hogarth, Stuart Turner. Standards-Based, Open-Source Electronic Health Record Systems: A Desirable Future for the U.S. Health Industry. *Telemedicine and e-Health*. April 1, 2008, 14(3): 284-288.

The aim of our realization

- Was initially to respond to the needs of our surgical Intensive Care Unit (12 beds)
- Actually, is to enhance the reliability of the system and allow the utilisation by several units in our CHU (30 beds)

The constrains: a limited budget (Scientific foundation not able to support costly licences)

The retained solution: use of Open Source Resources

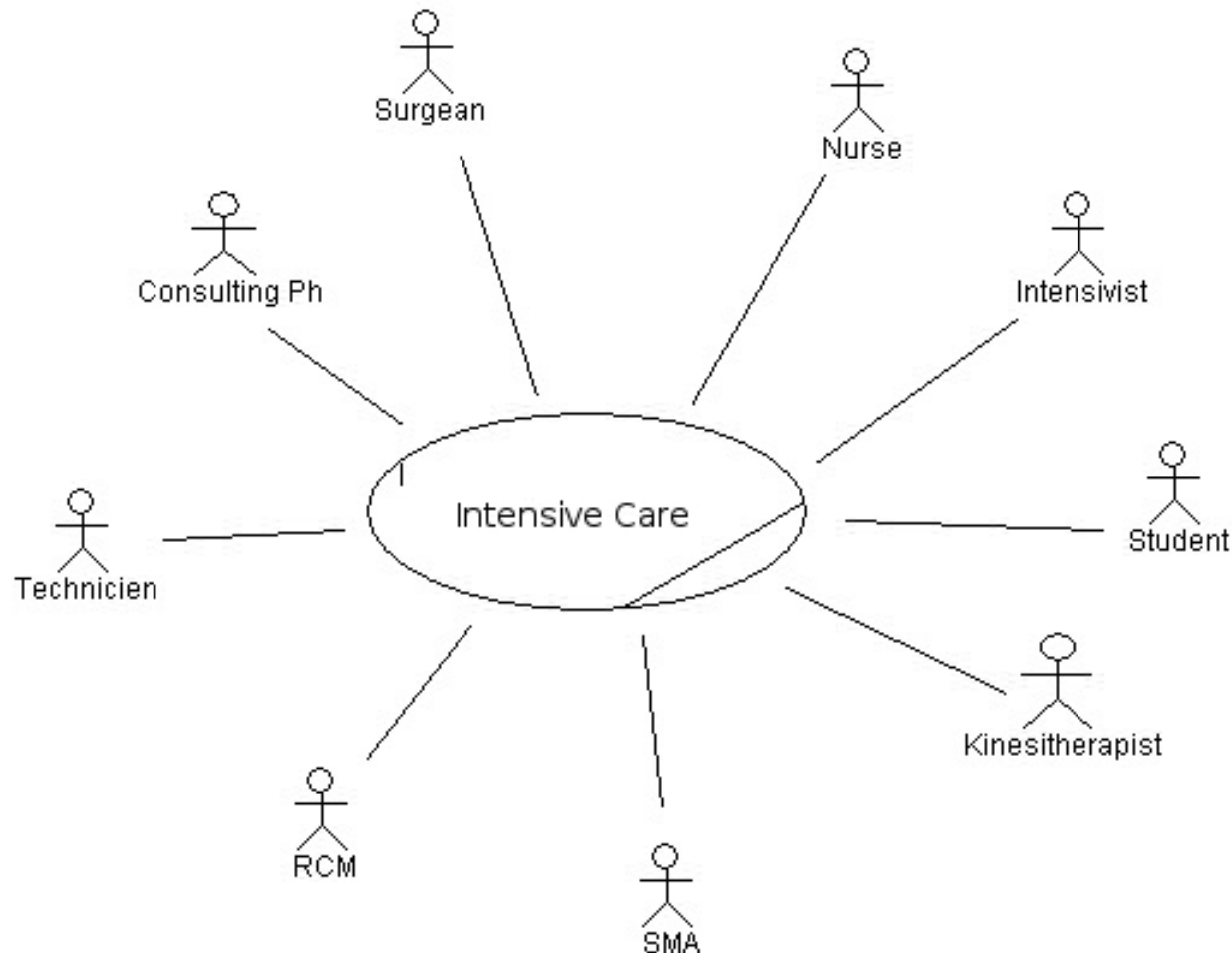
The requirements were to realize a medical electronic record system with:

- The patient history
 - Daily notes
 - Medical prescriptions and orders
 - Flow charts of bedside data
 - Medical activity recordings
 - Query for statistics, clinical audit and scientific studies.
-

Methodology used for the design and development

- Some modelling was performed based on
 - > the environment study,
 - > data flow and existing procedures analysis
 - Powered by the open source PostgreSQL database
 - The development follows a client server architecture with the client interface coded in C
 - The actual upgrade uses Ada and SparkAda languages
-

The Intensive Care Environment includes

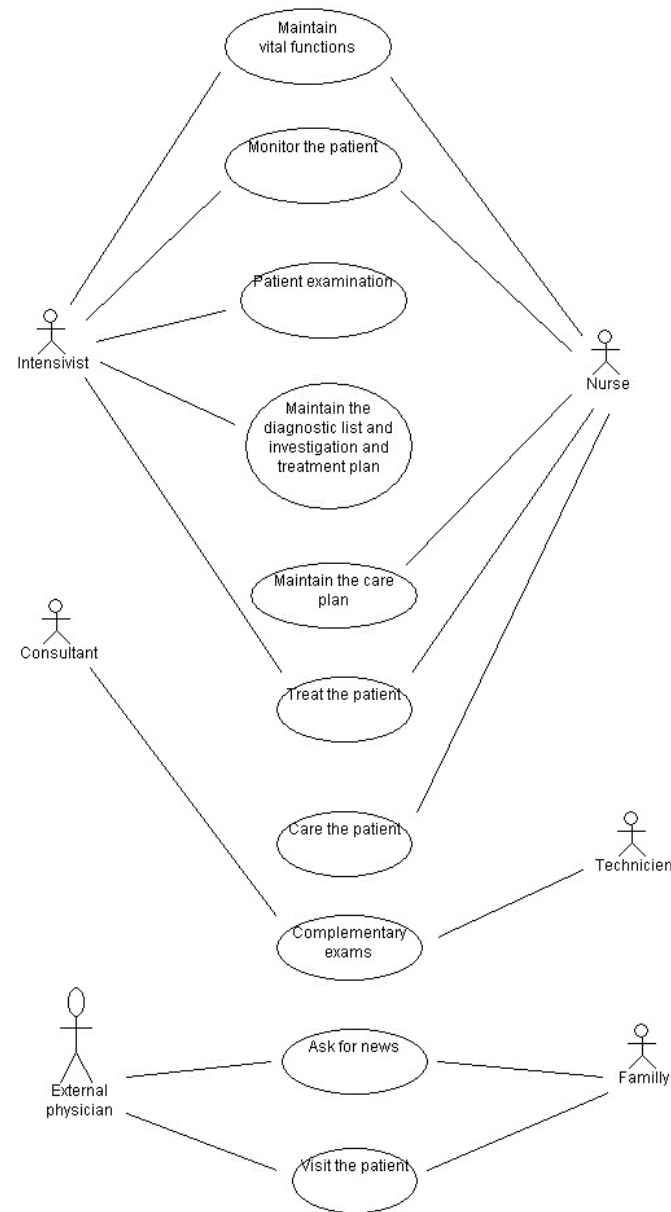


- A high number of workers

- * High numbers of interventions for every worker

- * Complexity due to simultaneous accesses

- * Necessity for a daily and continuous processing.



The system is powered by

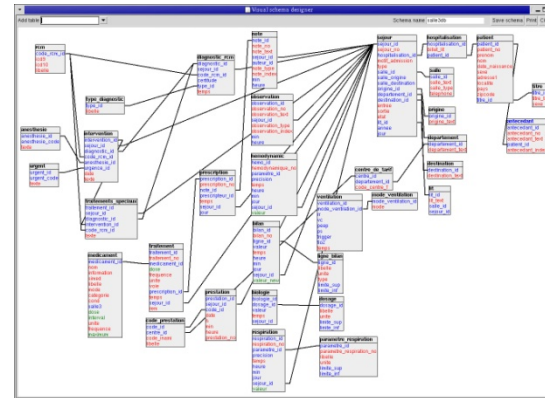


PostgreSQL

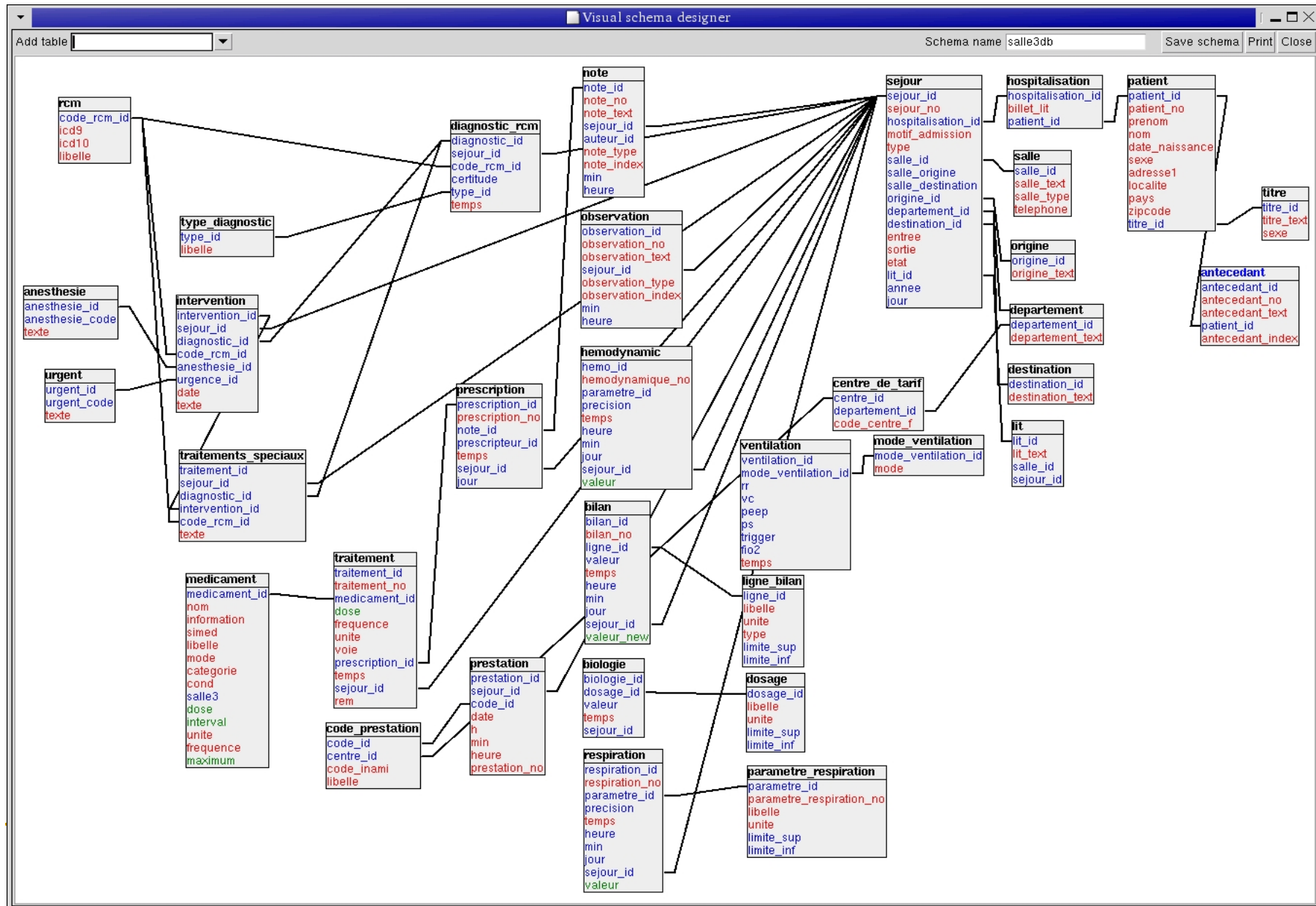
The world's most advanced
open source database.

Relational database.

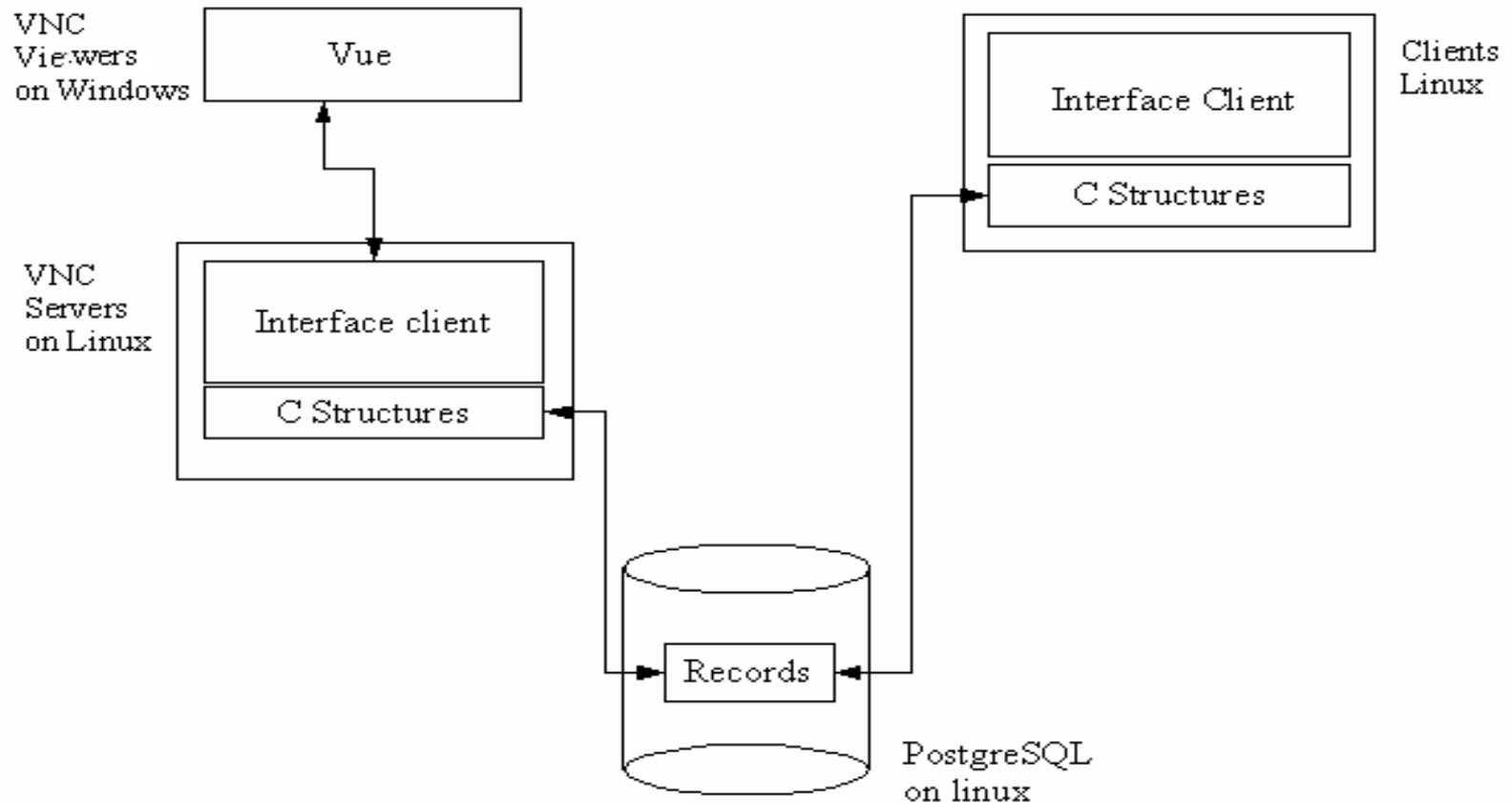
The database structure reflects the structure of the
electronic health record.



The database structure



The system is based on a client-server architecture, the interface first developed in c is now upgraded in Ada



The graphical interface uses
the GTK library,



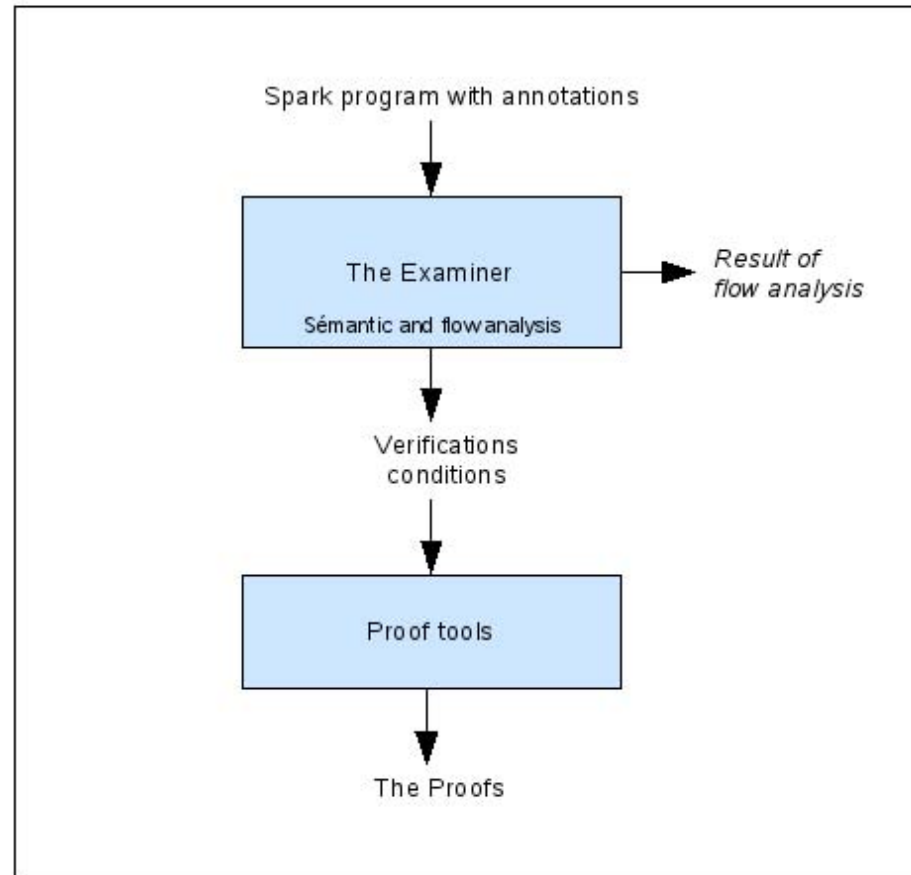
an object oriented library,
developed in c,
open source,

available on several platforms
and accessible from several programming
languages (python, ada...)

The problem of C

- Debugging is difficult because
 - Of the language used
 - Of the clinical environment (« Critical »)
- Portability of c is limited
- The Upgrade of the system is based on the Ada et Spark ada
 - heavy types languages
 - allowing static analysis before compilation
 - good portability of code sources.

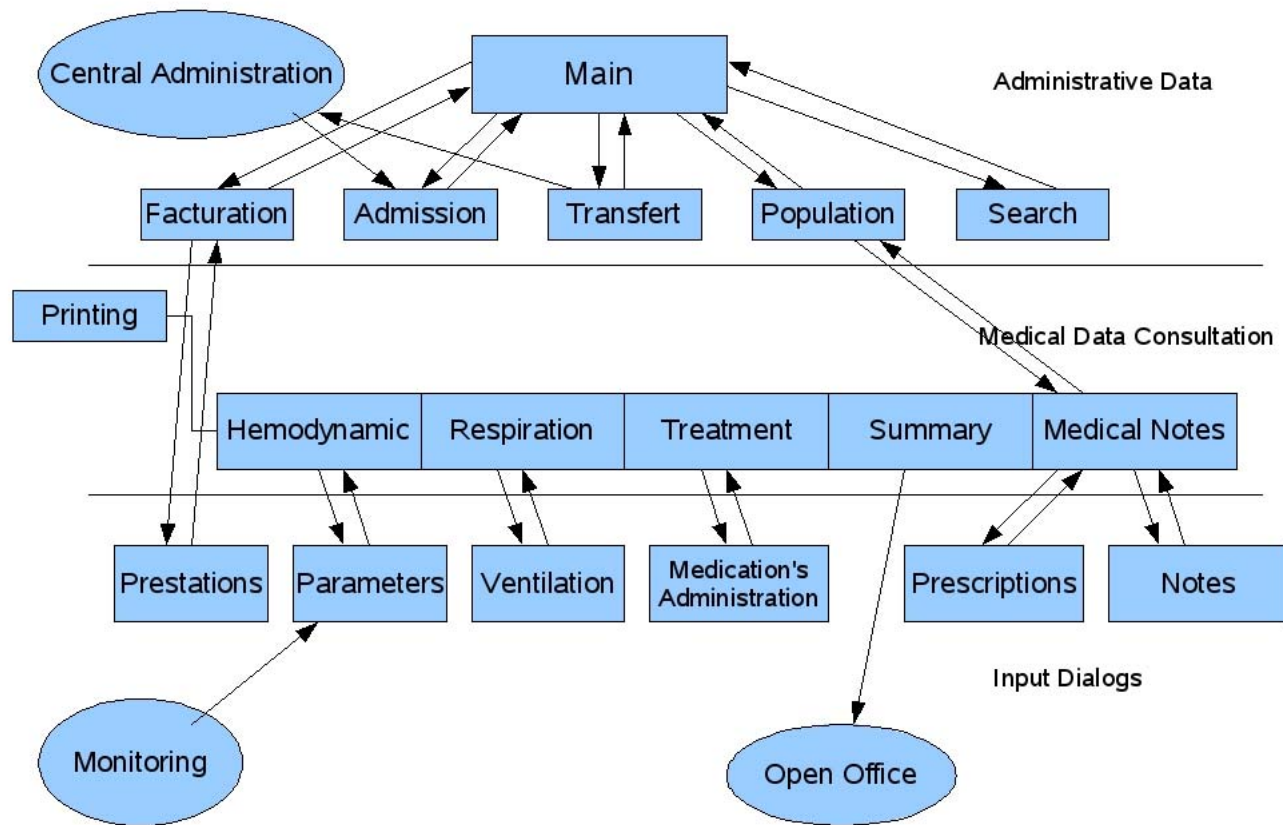
SparkAda



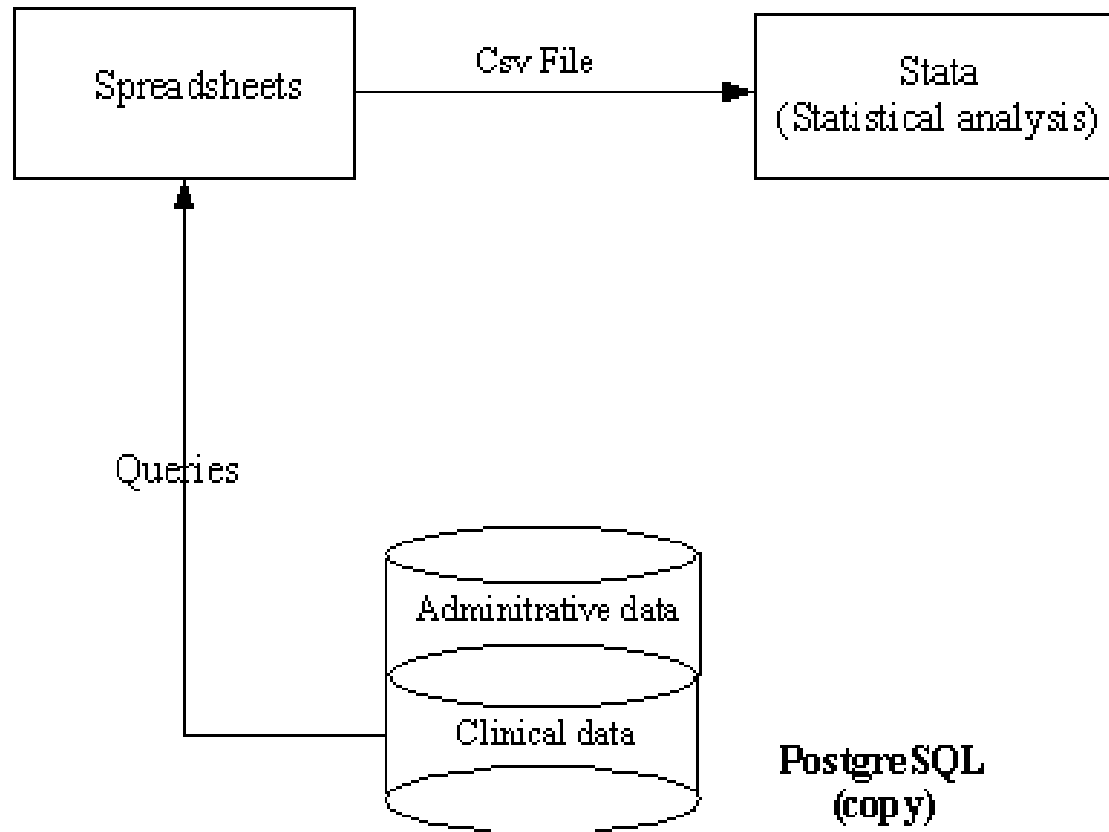
Application functionalities

- Notes containing patient's history, observation and treatments
 - (Flow charts for vital signs, in-out balances, ventilation parameters and settings)
 - Prescription and medication administration
 - Scoring possibilities for patient's classification
 - Summary of Intensive Care hospitalisation
 - Encoding of medical activities.
-

Application functionalities



Data analysis and retrospective study



Example of retrospective study: Review of factors affecting dialysis requirements

Potentially nephrotoxic antibiotic like Vancomycin have been incriminated as causes of increased need of hemodialysis in intensive care patients *.

- * Eichhorn M.E, Wolf H, Kuchenhoff H, Joka M, Jauch K.W, Harti W.H.
Secular trends in severe renal failure associated with the use of new antimicrobial agents in critically ill surgical patients.
Eur J Clin Microbiol Infect Dis (2007) 26: 395-402.
-

Example of retrospective study: Review of factors affecting dialysis requirements

We wanted to evaluate the incidence of Vancomycin administered as continuous intravenous infusions on hemodialysis needs in our patients compared to others antibiotic agents.

For that purpose we reviewed the evolution of 1263 consecutive patients and analysed the effect of all antibiotics treatments on hemodialysis-hemofiltration (HH) requirements, using univariate and multivariate logistic regression. Data for these patients were extracted by queries on the database of the system.

Example of retrospective study: Review of factors affecting dialysis requirements

- 37 patients of 1263 (2.9%) received HH. 549 (19.71%) patients received antibiotics.
 - At the univariate analysis, Vancomycin, Meropenem, Piperacilin-Tazobactam and Fluconasol treatments were significantly associated with the necessity of HH.
-

Example of retrospective study: Review of factors affecting dialysis requirements

Variables	Odds Ratio	P value	95% CI (low)	95%CI (high)
Vancomycin	4.75	0.002	1.78	12.70
Meropenem	5.67	0.006	1.65	19.48
Pip-Tazo	4.14	0.001	1.82	9.42
Diflucan	5.68	0.005	1.69	19.08

Vancomycin, Meropenem, Piperacilin-Tazobactam and Fluconasol treatments were also significantly associated with the necessity of HH at the multivariate logistic regression

Example of retrospective study: Review of factors affecting dialysis requirements

The incidence of HH requirements following the use of Vancomycin was not significantly different (Pearson Chi-square, $p = 0.106$) from the incidence following the use of Meropenem, Piperacilin-Tazobactam and Diflucan also used in severe sepsis.

These results did not confirmed that our use of Vancomycin increases HH requirements more than other antibiotics used in severe sepsis.

Practical use of the application

- First use in February 2004
 - Treatment of more than 4000 patients
 - Integrity of data preserved
 - Less than 5 hours interruption over one year
 - Every day use
 - Retrospectives studies
-

The application

The application

The screenshot displays the 'Soins Intensifs' application interface. The main window features a menu bar with 'Patient', 'Parametres', 'Tools', and 'Aide'. Below the menu is a toolbar with icons for 'Connection', 'Deconnection', 'Admission', 'Lit', 'Dossier', 'Mettre a jour', 'Transfert', 'Cloturer', 'Rechercher', and 'Quitter'. The main area contains a table with the following columns: 'Lit', 'Titre', 'Nom', 'Prenom', 'Date de naissance', 'Date d'admission', 'Motif d'admission', and a status column. The table lists 11 patients. To the right, there are two smaller windows: 'Admission' and 'Urgences'. The 'Admission' window has fields for 'Billet de lit', 'Patient' (No de patient, Titre), and 'Admission aux soins intensifs' (No de séjour, Date / heure, Motif, Type de patient). The 'Urgences' window has a 'Urgences' label and a 'Validier' button.

Lit	Titre	Nom	Prenom	Date de naissance	Date d'admission	Motif d'admission	Status
1	Mme	*****	*****	1929-12-26	2007-08-04 12:18	détresse respiratoire	U
2	Mr	*****	****	1923-05-18	2007-08-01 17:39	DETRESSE RESPIROTOIRE	U
4	Mr	*****	*****	1970-03-21	2007-07-20 00:34	hemothorax	U
6	Mr	*****	*****	1928-05-17	2007-07-13 15:11		U
7	Mme	*****	*****	1938-01-01	2007-07-29 10:02		U
8	Mme	*****	*****	1926-04-04	2007-08-06 10:07	Laparotomie	U
10	Mr	*****	*****	1985-08-29	2007-08-06 10:38	LEFORT	U
11	Mme	****	*****	1941-02-21	2007-08-05 21:48	Malaise	U

Medical notes

☐ Soins Intensifs

Patient : Lit 4 ***** 1970-03-21Admission : 2007-07-20 00:34

HemodynamiqueIN-OUTVentilation-GazosBiologieTraitementDossier medicalResumeRenseignement patient

Note et examenPrescriptionsImprimer

00:54 20.07.2007
00:58 20.07.2007
08:55 20.07.2007
08:57 20.07.2007
10:54 20.07.2007
15:57 20.07.2007
00:39 21.07.2007
08:50 21.07.2007
08:54 21.07.2007
11:05 22.07.2007
11:08 22.07.2007
09:03 23.07.2007
09:12 23.07.2007
07:37 24.07.2007
07:42 24.07.2007
07:52 25.07.2007
08:04 25.07.2007
08:20 25.07.2007
13:37 25.07.2007
07:24 26.07.2007
07:27 26.07.2007
07:48 27.07.2007
07:52 27.07.2007
08:27 28.07.2007
08:28 28.07.2007
08:29 28.07.2007
08:02 29.07.2007
08:07 29.07.2007
07:14 30.07.2007
07:20 30.07.2007

00:54 20.07.2007 -- *****

MOTIF D'ADMISSION :
hemothorax après défenestration

MEDECIN TRAITANT :

MEDECIN REFERANT :
Dr.Callewier A

RENSEIGNEMENT PERSONNEL :
Alcool +++
tabac ++

AFFECTION ACTUELLE :
ammené par le smur pour C2H5OH et passage à travers une vitre avec des plaie dans l'hypochondre Dte et une hemothorax

ANTECEDENTS :
ni connu

ALLERGIES :
ni connu

RESETMonitoringVAXSMAFermer

Notes edition

☐ Editeur de notes

Patient : Lit 3 1941-09-30 Admission : 2007-06-23 12:34

Motif d'admission

CIV post STEMI choc

Medecin traitant

Dr
Ave Karreveld 76
1081 BXI
02 411 63 21

Affection actuelle

admise aux urgences le 21/06/07 à 20h30 pour infarctus du myocarde (envoi par MT)
STEMI subaigu: malaise il y a 4 jours avec lipothymies map à l'hopital d'Oostende.
Envoyée aux urgences par le MT sur base de Tropono élevées.
Diagnostic d'une CIV sur nécrose apicale récente - Hypotension artérielle et surcharge pulmonaire

Note et examen

Signature :

OK Annuler

- Motif d'admission
- Medecin traitant
- Medecin referant
- Renseignement personnel
- Affection actuelle
- Antecedents
- Allergies
- Traitement habituel
- Liste des diagnostics
- Note
 - Scores
 - Glasgow Coma
 - Apache II
 - SOFA
 - Lung Injury Sevrity
- Examen physique
 - Evolution
 - Nouveau diagnostic
 - Bacterio

Glasgow Coma Scale

(E) Ouverture des yeux	Spontanée	E = 4
	à la voix	
	à la stimulation douloureuse	
	aucune	
<hr/>		
(V) Réponse verbale	Orienté et s'exprimant	V = 5
	Desorienté mais s'exprimant	
	Réponses inappropriées	
	Sons incompréhensibles	
	Aucune	
<hr/>		
(M) Réponse motrice	À la commande	M = 6
	Réponse motrice localisée	
	Retrait à la douleur	
	Mouvements anormaux en flexion	
	Mouvements anormaux en extension	
	Flaccidité, pas de réponse motrice	
<hr/>		
		T = 15

[illegible]

Prescription

salle3db2

Patient : Lit 4 ***** 1970-03-21 Admission : 2007-07-20 00:34

Medicament : dobutrex 5.00 mcg / IVC

Nom	Libelle	Unites	Mode
humiline regula		ml	perfusion
somatostatine		mcg/kg/min	IVC
corotrope		mcg	IV
dobutrex		mg	per os
dynatra		gr	IM
levophed		unites	SC
diprivan		milliers d'U	Aerosols
glazidim		millions d'U	SG
vancocin		mg/h	transfusion
		mcg/h	péridural
		ml/h	externe
		meq	
		comp	

Dose 5.00 Frequence

Remarques

Info Ajouter Modifier Enlever

19:10 13.08

Prescriptions

—13:43 13.08 vitamine b6 100.00 mg / perfusion /24h

—07:24 06.08 vitamine pp 100.00 mg / perfusion /24h

—08:02 05.08 tiapridal 400.00 mg / perfusion /24h

—08:06 04.08 kabiven 1500.00 ml / perfusion Structo-Kabiven

—10:46 03.08 calcium chlor 1.00 gr / perfusion

—10:39 03.08 konakion 10.00 mg / perfusion 2x/24h

—11:21 02.08 kcl 40.00 meq / perfusion /24h

—07:45 02.08 gl5%+nacl0.45 1000.00 ml / perfusion /24h

—07:42 01.08 vitamine b1 0.00 mg / perfusion /24h

—07:40 31.07 humiline regula 1.00 unites / IVC ad gl 100-150

—07:20 30.07

Signature :

Valider Annuler

Medication administration

Soins Intensifs

Patient : Lit 3 1941-09-30 Admission : 2007-06-23 12:34

Hemodynamique IN-OUT Ventilation-Gazos Biologie **Traitement** Dossier medical Resume Renseignement patient

Traitement immediat Details / heure Imprimer

7 h 8 h 9 h 10 h 11 h 12 h 13 h 14 h

TRAITEMENT du 17.7.2007

Prescription 08:00 17.07

perfusion

clinomel 1000.00 ml /24h + nonan et cernevit, + dip

gl.5%+nacl.0.45 250.00 ml /24h

albumine 100.00 ml /24h

IVC

insuline actra 0.00 unites pour glycemie entre 90-120

cordarone 300.00 mg /24h

sufenta 10.00 mcg/h

dormicum 2.00 mg/h

dobutrex 3.00 mcg/kg/min

IV

zantac 50.00 mg 3x/j

maxipime 1.00 gr 1x/j

Prescription 12:39 16.07

perfusion

heures 12 minutes 0

sufenta 10.00 mcg/h IVC

Volume 0 ml

Valider Annuler

RESET Monitoring VAX SMA Fermer

Vital signs

Soins Intensifs

Patient : Lit 4 ***** 1970-03-21 Admission : 2007-07-20 00:34

Hemodynamique	IN-OUT	Ventilation-Gazos	Biologie	Traitement	Dossier medical	Resume	Renseignement patient
---------------	--------	-------------------	----------	------------	-----------------	--------	-----------------------

	12 h 0	14 h 0	16 h 0	18 h 0	20 h 0	21 h 0	23 h 30	2 h 0	4 h 0
TA syst	126	95	115	101	108	125	158	100	121
TA diast	79	71	77	70	71	73	77	64	74
TA moy	91	76	86	77	114	86	97	73	86
RC	109	120	111	114	110	108	107	103	106
PVC	2	3	3	2	2	5	5	0	0
SAO2	98	96	98	100	100	98	100	100	99
PAP syst									
PAP diast									
PAP moy									
PAPO									
SvO2									
Débit									
t _e	38.0	37.8	37.9	37.7	37.8	37.8	37.9	37.6	37.9

RESET Monitoring VAX SMA Fermer

Summary and report

Patient : Lit 1 ***** 1929-12-26

Hemodynamique IN-OUT Ventilation-Gazos Biologie Traitement Dossier medical

Imprimer Lettre de sortie Open office

MOTIF D'ADMISSION :

- AFFECTION ACTUELLE
- ANTECEDENTS
- ALLERGIES
- TRAITEMENT ANTERIEUR
- BACTERIO
- LISTE DES DIAGNOSTICS
- EVOLUTION
- TRAITEMENT ACTUEL

MOTIF D'ADMISSION :
détresse respiratoire

AFFECTION ACTUELLE :
Détresse respiratoire aigue postop J15 avec anémie pers

ANTECEDENTS :
HTA
FA paroxystique
maladie de Puytren
dyspnée stade 3 non investiguée
dyslipidémie
cholecystectomie
HRT
TVP MI ss sintron (5 épisodes)

ALLERGIES :
non connu

TRAITEMENT ANTERIEUR :
bisoprolol 5 mg

BACTERIO :

LISTE DES DIAGNOSTICS :
détresse respiratoire <OPA?, Embolie pulmonaire sur TVP

EVOLUTION :

TRAITEMENT ACTUEL :
Prescription 09:19 06.08

Sortie.sxw - OpenOffice.org 1.1.2

Fichier Édition Affichage Insertion Format Outils Fenêtre Aide

/home/prog/Sortie.sxw

Opening Courrier 12 G i S

2 1 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Centre Hospitalier universitaire Brugmann
Soins Intensifs Chirurgicaux

Soins Intensifs Chirurgicaux,
CHU Brugmann,
4 Place Van Gehuchten,
1020 Bruxelles.
Tél : 02/4772315.

Professeur Jacques Massaut,
Chef de Clinique.

Docteur Pascal Reper,
Chef de Clinique Adjoint.

Docteur Oaleed Noordally
Chef de Clinique Adjoint

Bruxelles le

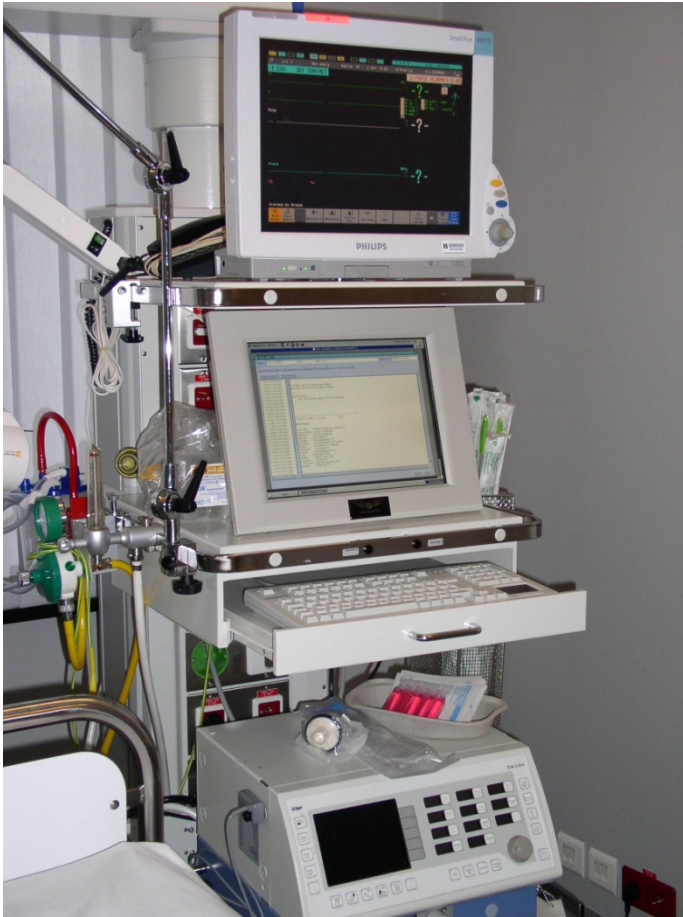
Résumé de l'observation de Mme ***** née le 1929-12-26,
admise à l'USI chirurgicale le 2007-08-04 12:18,
Billet de lit : *****.

MOTIF D'ADMISSION :
détresse respiratoire

Page 1 / 3 Première page 75% INS STD HYP *

RESET Monitoring VAX SMA Fermer

Accessibility



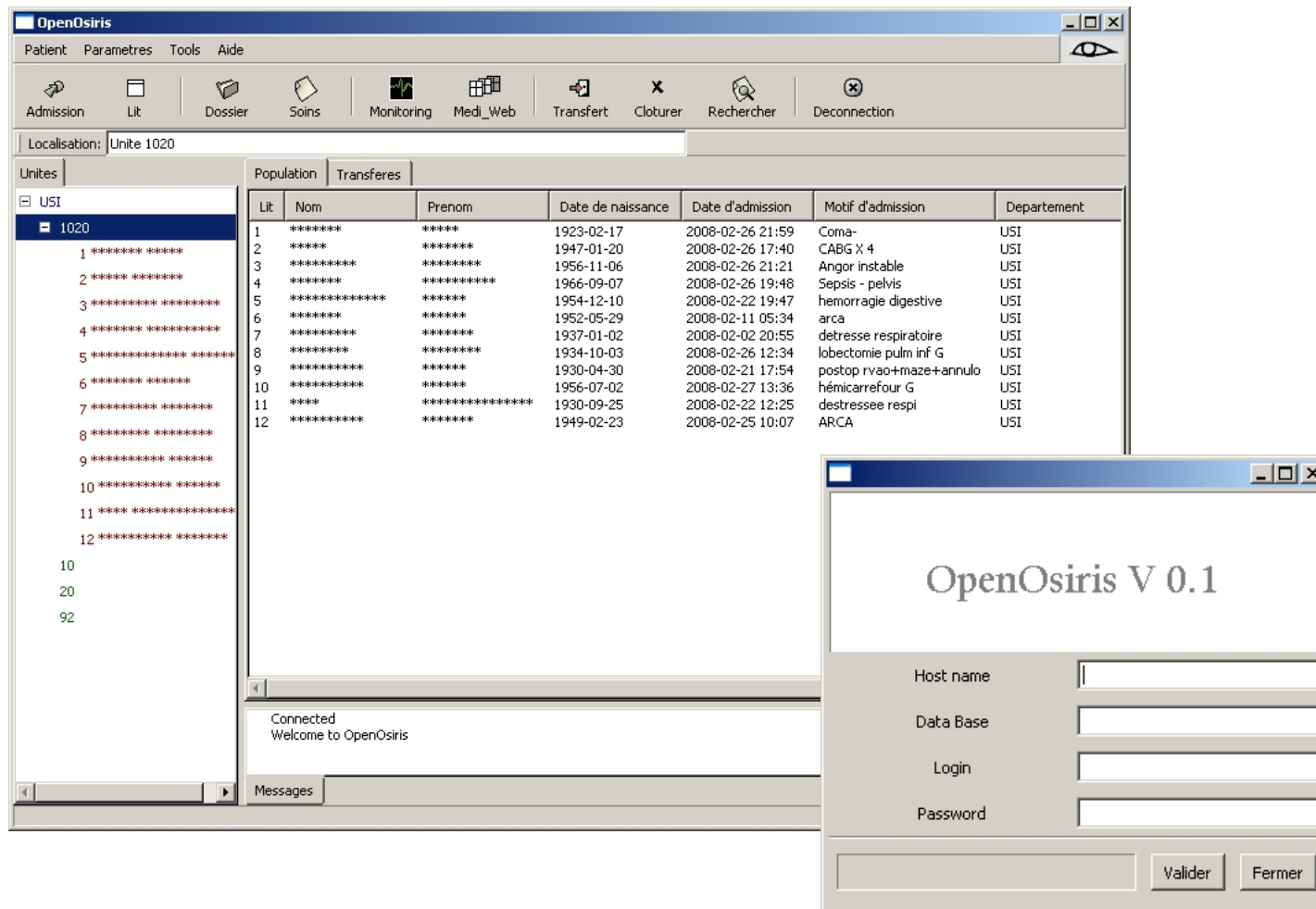
At desks
an at the bedside

The actual upgrade must allow

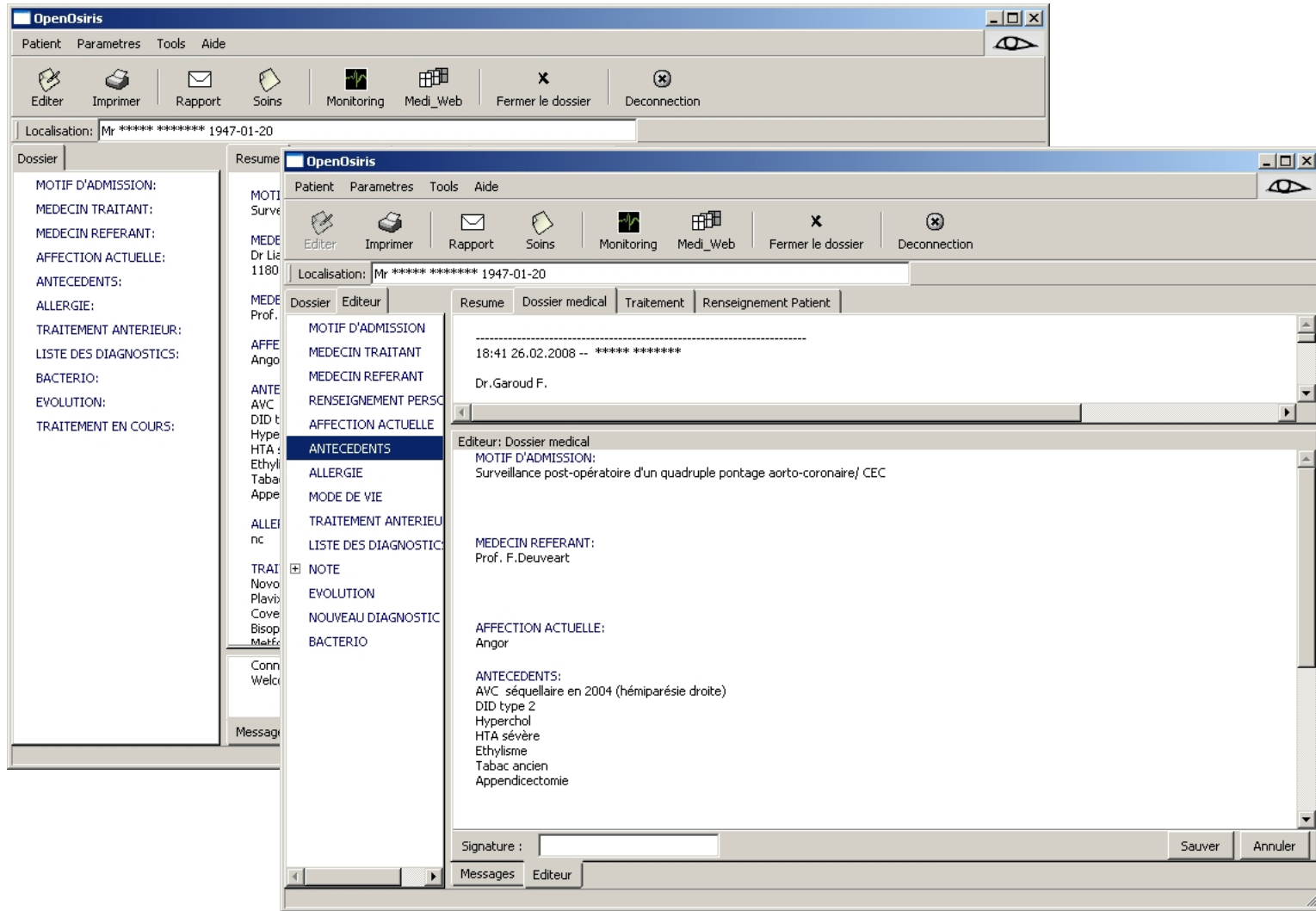


- A better integration with others medical applications
- Multi-platform capabilities
- Enhancement of stability and Security and Identification
- Conviviality of the client interface
- To deserve several units
- or departments

Multi platform upgrade



More convivial



And better integrated

The screenshot displays a medical software interface with multiple windows. The main window, titled "Portail AGFA - BR-MWEB03 - QDOC1 - Microsoft Internet Explorer", shows a patient's ECG and vital signs. The patient's name is "Mr *****" and the date is "1947-01-20". The ECG is labeled "Lit 7" and "2290772". The vital signs include "FC 103", "ESV 0", "ST-II -0.2", "ST-III -0.1", "ST-aVR 0.2", "ST-aVL 0.0", "ST-aVF -0.1", "ST-V 0.0", "ST-MCL 0.0", and "POULS 103". The blood pressure is "PA 122/62(83)". The interface also includes a "Fenêtre Patient" window and a "Centre d'information Web" window. The "Fenêtre Patient" window shows a list of patient data, including "Lit 7", "2290772", "TACHY SINUSALE", "FC 103", "ESV 0", "ST-II -0.2", "ST-III -0.1", "ST-aVR 0.2", "ST-aVL 0.0", "ST-aVF -0.1", "ST-V 0.0", "ST-MCL 0.0", and "POULS 103". The "Centre d'information Web" window shows a list of patient data, including "Lit 7", "2290772", "TACHY SINUSALE", "FC 103", "ESV 0", "ST-II -0.2", "ST-III -0.1", "ST-aVR 0.2", "ST-aVL 0.0", "ST-aVF -0.1", "ST-V 0.0", "ST-MCL 0.0", and "POULS 103".

OpenOsiris
Patient Paramètres Tools Aide

Editer Imprimer Rapport Soins Monitoring Medi_Web Fermer le dossier Deconnection

Localisation: Mr ***** 1947-01-20

Dossier
18:41 26.02.2008
09:09 27.02.2008
09:17 27.02.2008
18:18 26.02.2008

Resume
IVC :
dobu
dorn
sufe
ryde
hum

IV :
zant
perf
cont
cefa

09:09 27.02.2008
Dr P Repe
NOT

J01 post C
Situation f
Bilan +16
Extubation
gazo 7.37
Patient ca

Examen p
T° 36

Connecter
Welcome

Messages

Portail AGFA - BR-MWEB03 - QDOC1 - Microsoft Internet Explorer
File Edit View Favorites Tools Help

Address http://mwebhbr/qweb/

Portail AGFA

Notifications
Hôpital
--- 28/11/2006 ---
Information sur
imagerie à disposition
dans le manuel

Autres
LAB : The abnormal
results are between
brackets and are red
colored

ECG
multidérivation
Fenêtre Patient
Revue 12
dérivations
12 dérivations
capturées
Revue Alarmes
Revue Tendances
Revue Evénements
Revue Courbes
Revue ST

Pour afficher un
autre contexte
patient,
sélectionner **Liste
Patients**

Pour rechercher
un patient,
sélectionner
**Recherche
patient admis**

Administration
Gestion clinicien

Pour terminer la

Centre d'information Web - Microsoft Internet Explorer
File Edit View Favorites Tools Help

Address http://mwebhbr/qweb/

Rechercher Traductions Ouvrir session Y! Mail Questions/Réponses Contrôles Y! Messenger Mon Yahoo!

Fenêtre Patient
Lit 7 2290772

10:37 C2 DEF CONTACT

II TACHY SINUSALE FC 103 ESV 0
1 mV indST ?
V ST-I -0.1
1 mV ST-II -0.2 ST-III -0.1
aVR ST-aVR 0.2 ST-aVL 0.0
1 mV ST-aVF -0.1 ST-V 0.0
PA ST-MCL 0.0 POULS 103

PA 122/62(83)

un10db

Pas alarmes audibles Courbes retardées PHILIPS

Page générée : 10/01/08 15:43:13
Copyright © 2001 Philips Electronics North American Corp. Tous droits réservés.

Local intranet

Conclusions:

- The system developed from open source components is effective and able to respond to requirements of intensive care environments
 - By the use of open source components we were able to adapt the software to the pre-existing organisation at low cost, facilitating the acceptability by the staff.
-

Conclusions:

- The knowledge of the database structure allowed us to conduct retrospective clinical studies based on data queries and analysis
 - Of course the system is far from perfect and does not cover all the domains of intensive care, but is robust and effective.
-