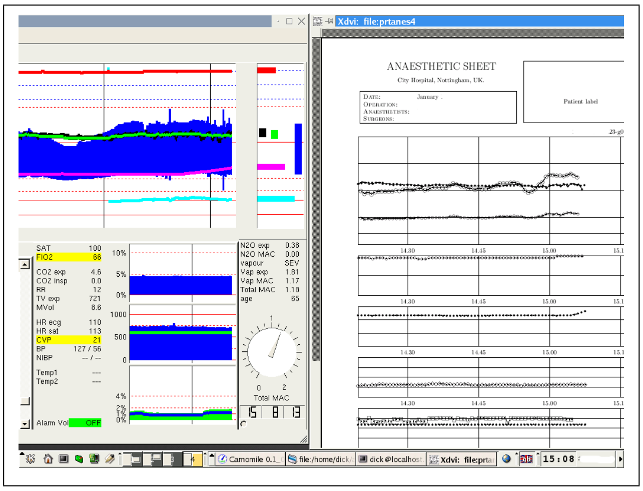
An Open Source Anaesthesia Workstation (Linux)

revision 09α



SAT 100
FIO2 66
CO2 exp 4.6
CO2 insp 0.0
RR 12
TV exp 721
MVol 8.6
HR ecg 110
HR sat 113
CVP 21
BP 127 / 56
NIBP -- / --
Temp1 ---
Temp2 ---
Alarm Vol OFF

N2O exp 0.38
N2O MAC 0.00
vapour SEV
Vap exp 1.81
Vap MAC 1.17
Total MAC 1.18
age 65

ANAESTHETIC SHEET
City Hospital, Nottingham, UK.
Date: January
Operation:
Anaesthetists:
Surgeons:
Patient label

Richard W. D. Nickalls
Simon Dales
Adrian K. Nice

The single biggest problem we face is that of visualisation

Richard P. Feynman (1918–1988) [1]

[1] The Mathematical Gazette (1996); 80, 267.

An open source Anaesthesia Workstation

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r w d n

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revision 09α

Preface

This document brings together in one place most of the available information regarding the development work, files, programs and screenshots relating to the current version of our open source Anaesthetic Workstation computer program, which was used in one of the thoracic operating theatres during the period 2002–2006. This document is still ‘work in progress’, and will therefore be updated periodically.

This project started with an MS-DOS prototype (written by RWD Nickalls during 1994-2001) the details of which are also on this website (`http://www.nickalls.org/dick/xenon/rwdnXenon.html`).

RWD Nickalls (2009)

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Part I

Background

Chapter 1

An anaesthesia workstation

ch-intro

1.1 Introduction

Since 1994 RWDN has run an on-going research-project to develop an open-source anaesthsia workstation for free use by the NHS in the operating theatre. What started as a small project to automate the production of the anaesthetic record, has since developed into a clinically-useful support tool for anaesthetists.

During the period 1994–2001 we developed a working theatre-based prototype MS-DOS program[1], which was used in the thoracic operating theatre (City Hospital). A paper anaesthesia record (for the patient notes) was output using the open-source programs GNUplot (for graphic trends) and LaTeX 2ε(for typesetting). Much of the initial work relating to interfacing medical devices via the serial port was published as a book by Cambridge University Press (Nickalls and Ramasubramanian, 1995).

In 2002 Simon Dales joined the project and the program was ported to Linux (see Section 1.3), and the program was extended to include alarms, some basic decision-support, as well as the calculation and visulisation of various useful so-called *value-added* real-time parameters, for example, age-dependent MAC[2] (Nickalls and Mapleson 2003).

1.2 Difficulty with funding and R&D

During the past eight years or so we have tried to collaborate with various university departments with a view to R&D. Discussions with the Nottingham University Departments of Computing and Department of Electrical and Electronic Engineering in 2005 did not lead anywhere owing to lack of funding. Unfortunately funding has still not been forthcoming (an EPSRC grant application in conjunction with Dept Med Physics, Liverpool Univ Hosp was rejected—see details below), and therefore serious development stalled. However, more recently, a collaboration with our own Medical

[1] The original version was in QuickBasic 4.5. It was later ported to PowerBasic 3.5, in order to accommodate the 11-bit serial data-frame used by the Datex AS/3 anaesthesia monitors.

[2] Minimum Alveolar Concentration (MAC) of an anaesthetic agent is an index of anaesthetic potency. A typical anaesthetic is associated with approximately 1–1·2 MAC.

Physics department has resulted in some ongoing development, which will be detailed in due course. These ventures are summarised below.

Collaboration with Leicester University—2001

During the academic year 2001–2002 we formed a collaboration with the Department of Electronic & Software Engineering, University of Leicester, UK), with a view to porting the existing program to the Linux operating system and making several enhancements. During this period four engineering students worked on parts of the program for their final year practical modules. Unfortunately however, the relatively short time allowed the students for their project was insufficient for a prototype to be developed, and the project terminated after one year.

Collaboration with Liverpool University — 2002

Significant interest in this project was shown by the Department of Clinical Engineering at the Royal Liverpool University Hospital. Unfortunately, however, a joint grant application (2004) to the EPSRC (Engineering and Physical Sciences Research Council) in conjunction with the Department of Clinical Engineering (RLUH) to fund research and development was not successful.

Collaboration with Nottingham Trent University — 2005

In December 2005 we explored a collaboration with (Department of Computing and Informatics, Nottingham Trent University) with a view to rewriting the software and implementing a more robust and scalable architecture. Again financial support did not materialise.

Collaboration with Nottingham University Hospitals — 2008

In December 2008 we embarked (in conjunction with Professor R Mahajan, Department of Anaesthesia) on a collaboration with the Department of Medical Physics at the Nottingham University Hospitals, City Hospital Campus, with a view to further development.

1.3 The Linux project

Towards the end of 2002 we formed an ‘open-source’ collaboration with Simon Dales (Software engineer, Oxford, UK). During 2003–2004 the original program was rewritten from scratch for the Linux operating system—the data acquisition and display module in C/C++ by SD, and the printing & processing modules in Perl, GNUplot and LaTeX 2_ε by RWDN.

The resulting working ‘stand-alone’ Linux prototype has been ‘up-and-running’ in the ‘thoracic’ operating theatre at the City Hospital, Nottingham since 2004, used by both consultant and trainee anaesthetists, and has been very sucessful (see illustrations at the end). The program gives a continuous trend display of a variety of measured and derived parameters, as well as ‘help’ and other general information, allows inputting of drug and other information, and automatically prints out the Anaesthesia Record at the end of the operation in a form suitable to be placed directly into the patient’s notes as a final record. In time we would like to incorporate a suitable database, develop smart-alarm and decision-support software, extend the on-line help facility, and to explore connectivity with the hospital information system (HISS).

Support is 'in-house' by the Group members (see below). Electrical safety issues relating to the hardware are overseen by Ged Dean (Medical Physics, City Hospital); Linux support is by Adrian Nice (Department of Information and Computing Technology, City Hospital).

Several lecture presentations relating to this project have been given over the last few years (Nickalls 2008, 2005a, 2005b, 2004a, 2004b, 2004c; Nickalls and Dales 2003).

Group members

The project team consists of the following members.

- **Richard WD Nickalls**, Consultant Anaesthetist, Department of Anaesthesia, City Hospital, Nottingham, UK.
- **Simon Dales**, Software Engineer, PurrSoft, Oxford, UK (*simond@purrsoft.co.uk*).
- **Adrian K Nice**, Senior Systems Developer, Department of Information and Computing Technology, City Hospital, Nottingham, UK.
- **Ged Dean**, Clinical Engineer, Department of Medical Physics, City Hospital, Nottingham, UK.

1.4 Modules

The Anaesthesia Workstation project currently consists of four software components as follows (see screenshots at the end).

1.4.1 Printing & HTML front-end module

This is written in the Perl language (by RWD Nickalls) and coordinates data manipulation, graph plotting (using GNUplot), and typesetting (using LaTeX 2_ε). An electronic form of the *Anaesthesia Record* and associated data and programs is made available for easy viewing via a HTML front-end.

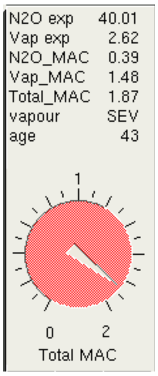
A paper version of the *Anaesthesia Record* in a format suitable for placing directly into the patient notes generated and is printed in the operating theatre at the end of anaesthesia. This consists of (a) the graphic trends (a series of 1-hour graphic records of measured parameters), and (b) the data log and keyboard entries (events, procedures, drugs given, blood lost etc.).

1.4.2 Data acquisition and display module

This is written in C/C++ (by S Dales) and uses the Qt library (standard with Linux systems). The program accesses serial data from the Datex AS/3 anaesthesia monitor and displays the data in trend and tabulat formats on the screen. The operating theatre PC runs Mandriva-Linux on a Dell Pentium PC.

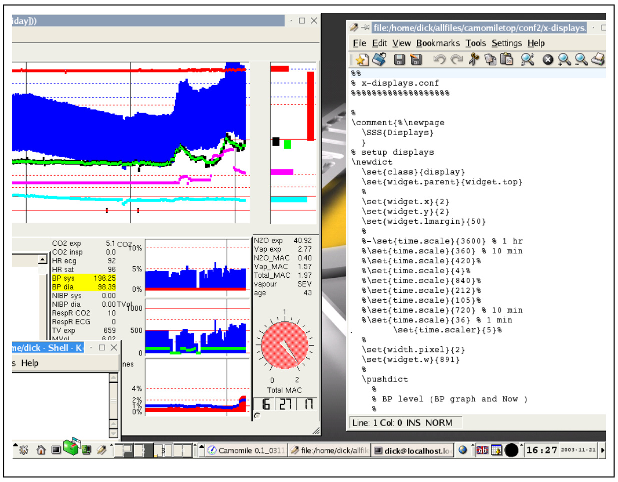
1.4.3 MAC display widget

The screen display incorporates a real-time MAC display widget (Figure 1.1), which is positioned in the lower right part of the main display screen (Figure 6.1). This widget displays the current MAC value, and implements an alerting colour change (to red) to warn the anaesthetists of an out of range value, and hence greatly facilitates the avoidence of inadvertent awareness of the patient under anaesthesia.



```
N2O exp      40.01
Vap exp       2.62
N2O_MAC       0.39
Vap_MAC       1.48
Total_MAC     1.87
vapour         SEV
age             43
```

Figure 1.1:
Example of the real-time age-corrected MAC-widget displayed by the anaesthesia workstation software (© Nickalls RWD and Dales S (1996–2009)) interfaced to the Datex S/5 monitor. If the corrected MAC is too low or too high (as shown in this case—total MAC 1·87) then, in addition to sounding an audible alarm, the dial of the MAC-widget turns red.



```
CO2 exp        5.1
CO2 insp       0.0
HR ecg          92
HR sat          96
BP sys      196.25
BP dia       98.39
NIBP sys      0.00
NIBP dia      0.00
RespR CO2       10
RespR ECG        0
TV exp         659
MVol          6.02
```

```
N2O exp      40.92
Vap exp       2.77
N2O_MAC       0.40
Vap_MAC       1.57
Total_MAC     1.97
vapour         SEV
age             43
```

```
%%
% x-displays.conf
%%%%%%%%%%%%%%%%%%%

%
\comment{%\newpage
  \SSS{Displays}
  }
% setup displays
\newdict
  \set{class}{display}
  \set{widget.parent}{widget.top}
  %
  \set{widget.x}{2}
  \set{widget.y}{2}
  \set{widget.lmargin}{50}
  %
  %-\set{time.scale}{3600} % 1 hr
  %\set{time.scale}{360} % 10 min
  %\set{time.scale}{420}%
  %\set{time.scale}{4}%
  %\set{time.scale}{840}%
  %\set{time.scale}{212}%
  %\set{time.scale}{105}%
  %\set{time.scale}{720} % 10 min
  %\set{time.scale}{36} % 1 min
          \set{time.scaler}{5}%
  %
  \set{width.pixel}{2}
  \set{widget.w}{891}
  %
  \pushdict
    %
    % BP level (BP graph and Now )
    %
```

Figure 1.2: Screenshot showing the MAC widget in a red-alert state. Note that the main display screen (pushed to the LHS) is designed so that all the important minute-to-minute data and alarm data is positioned on the RHS of the dmain display screen, and so allows the main display screen to be moved towards the left in order to view other data, files, or images as required. In this example a file is opened on the RHS of the PC screen.

The development of the real-time corrected-MAC widget follows from our earlier work on developing charts facilitating the determination of age-corrected MAC for anaesthetists (Nickalls and Mapleson 2003). These charts have also been included in an anaesthesia handbook (Nickalls 2006). Current work involves upgrading the MAC monitor to include the age, temperature and hair-colour corrections for MAC.

1.4.4 Decision-support module

This is an HTML information system offering decision-support, information on relevant drugs, medical conditions, etc. for anaesthetists in the operating theatre. The emphasis is on an intuitive well structured menuing system to enable items to be found easily and quickly. We hope to include suitable commercially available HTML texts as they come available.

1.4.5 A diabetes alert module

This is a program (in Perl) which makes use of the Linux Kalarm utility. Tk widgets are used to present a menu which allows the user to quickly set special alerts to prompt regular monitoring of blood glucose. A 'help' system allows the user to access protcols for the insulin management of diabetic patients during major surgery. The current version is only a prototype—we aim to greatly improve it by incorporating computer algorithms described by Mraz *et al.* (2008).

1.4.6 A drug-menu module

This is a pull-down drug menu from which the anaesthetists can select a drugname for addition to the drug record. This database is the standard DM+D EU drug-list database (downloaded from the NHS DM+D website) which is updated weekly. The list currently consists of about 1500 drugs.

References

- Mraz M, Kopecky P, Hovorka R and Haluzik M (2008). Intensive insulin therapy in the ICU; the use of computer algorithms. *British Journal of intensive Care*; 18, 129–134.

- Nickalls RWD (2008). *Linux goes to hospital.*
  Invited presentation to the *Nottingham Linux Users Group*, Nottingham, UK; September 18, 2008.

- Nickalls RWD (2006). MAC values. In: Allman KG and Wilson IH (Eds.) *Oxford Handbook of Anaesthesia*, 2006 (Oxford University Press, UK). pp. 1160–1162.

- Nickalls RWD (2005a). *Interfacing the PC to medical equipment.*
  Invited talk to the Nottingham & East Midlands Society of Anaesthesia (NEMSA) (Queen's Medical Centre; April 8, 2005). [mini-symposium on *Information Technology*]

- Nickalls RWD (2005b). *Linux in the operating theatre.*
  Invited presentation to the *Nottingham Linux Users Group*, Nottingham, UK; March 16, 2005.

- Nickalls RWD (2004a). *Critical Software in Anaesthesia—a doctor's view of what is needed.*
  Invited presentation to the *Institute of Physics and Engineering in Medicine* one-day conference on "The software medical device" (London; November 12, 2004).

- Nickalls RWD (2004b) *Age corrected MAC.*
Invited talk to the Nottingham & East Midlands Society of Anaesthesia (NEMSA) (Queen's Medical Centre; October 8, 2004). [mini-symposium on *MAC, elderly patients and confusion*]

- Nickalls RWD (2004c). An open-source anaesthesia workstation for the NHS. [Presentation to the *Patient Safety Network meeting*; IBIS Hotel, Birmingham, UK; April 27, 2004)

- Nickalls RWD and Dales S (2003). Camomile—an open-source anaesthesia record keeper and information system. [Presentation to the *Society for Computing and Technology in Anaesthesia* (SCATA). Manchester, UK; November 12-14, 2003]

- Nickalls RWD and Mapleson WW (2003). Age-related iso-MAC charts for isoflurane, sevoflurane and desflurane in man. *British Journal of Anaesthesia*; 91 (August), 170–174.
`http://bja.oupjournals.org/cgi/reprint/91/2/170.pdf`

- Nickalls RWD (1998a). Automated data capture—the doctor's view. [Invited talk at an industry workshop on *The Medical Information Bus (MIB)*.[3] Royal Angus Hotel, Birmingham, UK, (June 17, 1998). Organised by LinkTech Incorporated]

- Nickalls RWD (1998b). TEX in the operating theatre: an Anaesthesia application. [Invited presentation to the *Annual UK TEX Users Group meeting*, Cambridge, UK. (September 21–22, 1998)]

- Nickalls RWD (1998c). TEX in the operating theatre: an Anaesthesia application. *TUGboat*; 19, Proceedings of the 19th International TEX Users Group Meeting; p 7–9. (Toruń, Poland, August 17–20, 1998)
`http://www.tug.org/TUGboat/Articles/tb19-3/tb60nick.pdf`

- Nickalls RWD (1997). An Anaesthesia Record-keeping System using free text-based software. *SCATA News*, 6(1), 6. [Abstract of a presentation to the *Society for Computing and Technology in Anaesthesia* (SCATA). Glasgow, UK; November 21–22, 1996.]

- Nickalls RWD (1996). An automated Anaesthesia Record System using free text-based software. [Oral presentation to the *16th International Symposium on Monitoring and Computing in Anaesthesia and Intensive Care* in Rotterdam, Holland (May 1996)]

- Nickalls, RWD and Ramasubramanian R. (1995). *Interfacing the IBM-PC to medical equipment: the art of serial communication*. ISBN 0-521-46280-0; pp 402 (Cambridge University Press).

[3] A meeting concerned with the IEEE-1073 Standard regarding computer interfacing to Medical Devices.

1.5 Theatre and screenshots

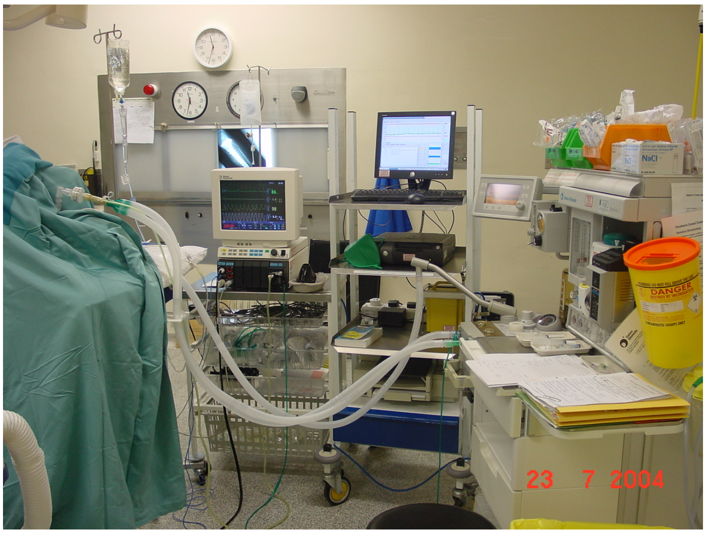
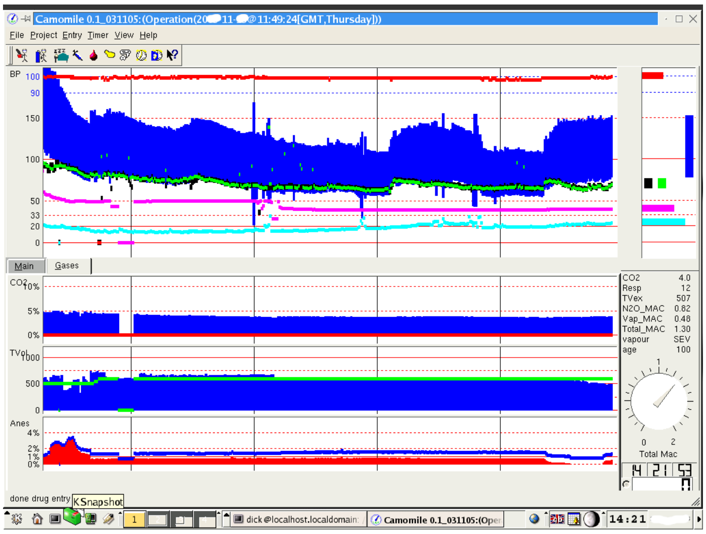


Figure 1.3: Program running in Theatre-1



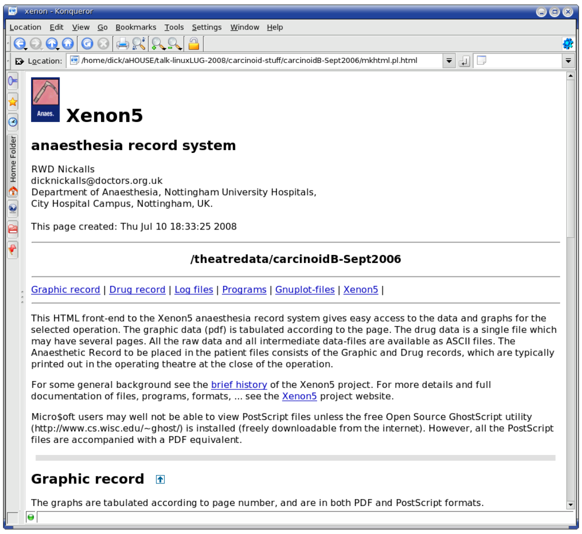
Camomile 0.1_031105:(Operation(20[redacted]11-[redacted]@11:49:24[GMT,Thursday]))

CO2	4.0
Resp	12
TVex	507
N2O_MAC	0.82
Vap_MAC	0.48
Total_MAC	1.30
vapour	SEV
age	100

dick @localhost.localdomain:

Camomile 0.1_031105:(Oper

Figure 1.4: Screen showing full width option for the lower half of the screen. Top half shows saturation (red), blood pressure (dark blue), ecg heart rate (green); oximeter heart rate (black), inspired oxygen (red), central venous pressure (pale blue)—current values are shown in top right window. Bottom half of the screen shows expired CO_2 (blue), inspired CO_2 (red), tidal volume TV (blue), respiratory rate (green), expired anes agent (sevoflurane, red) and age corrected MAC (blue)


xenon - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
Location: /home/dick/aHOUSE/talk-linuxLUG-2008/carcinoid-stuff/carcinoidB-Sept2006/mkhtml.pl.html
Home Folder
Anaes.

Xenon5

anaesthesia record system

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City Hospital Campus, Nottingham, UK.

This page created: Thu Jul 10 18:33:25 2008

/theatredata/carcinoidB-Sept2006

Graphic record | Drug record | Log files | Programs | Gnuplot-files | Xenon5 |

This HTML front-end to the Xenon5 anaesthesia record system gives easy access to the data and graphs for the selected operation. The graphic data (pdf) is tabulated according to the page. The drug data is a single file which may have several pages. All the raw data and all intermediate data-files are available as ASCII files. The Anaesthetic Record to be placed in the patient files consists of the Graphic and Drug records, which are typically printed out in the operating theatre at the close of the operation.

For some general background see the brief history of the Xenon5 project. For more details and full documentation of files, programs, formats, ... see the Xenon5 project website.

Micro$oft users may well not be able to view PostScript files unless the free Open Source GhostScript utility (http://www.cs.wisc.edu/~ghost/) is installed (freely downloadable from the internet). However, all the PostScript files are accompanied with a PDF equivalent.

Graphic record

The graphs are tabulated according to page number, and are in both PDF and PostScript formats.

Figure 1.5: Anaesthetic record — HTML front-end

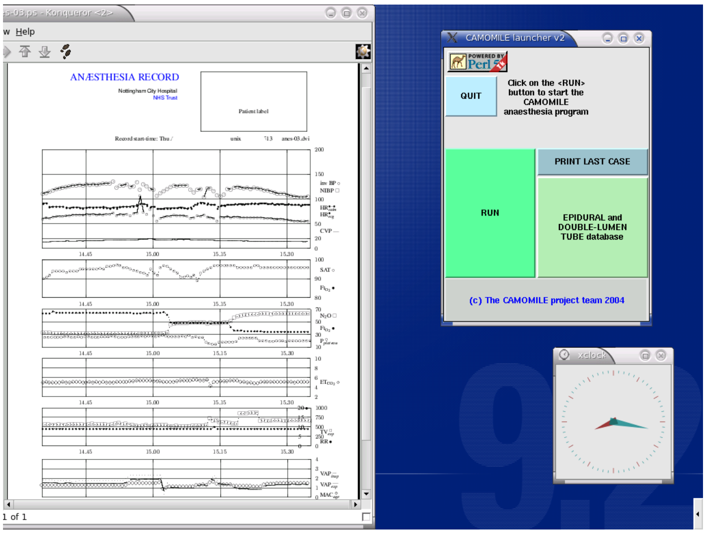
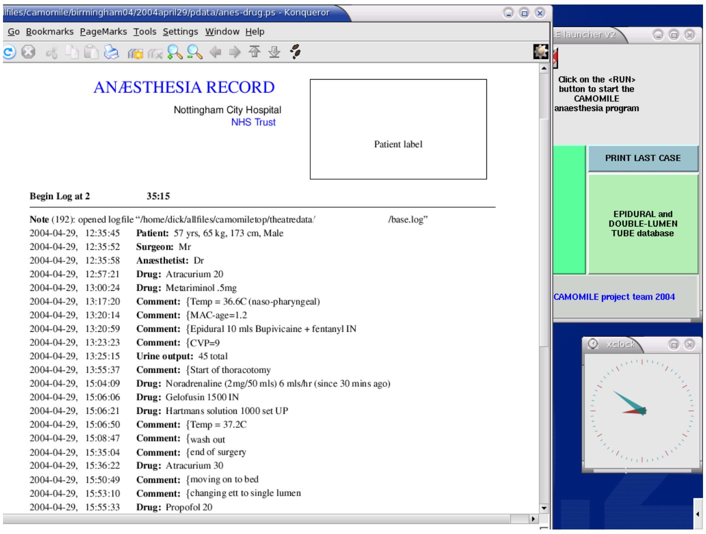


Figure 1.6: Anaesthetic record — graphic record


lfiles/camomile/birmingham04/2004april29/pdata/aries-drug.ps - Konqueror
Go Bookmarks PageMarks Tools Settings Window Help
E launcher v2
Click on the <RUN> button to start the CAMOMILE anaesthesia program
PRINT LAST CASE
EPIDURAL and DOUBLE-LUMEN TUBE database
CAMOMILE project team 2004
xclock

ANÆSTHESIA RECORD

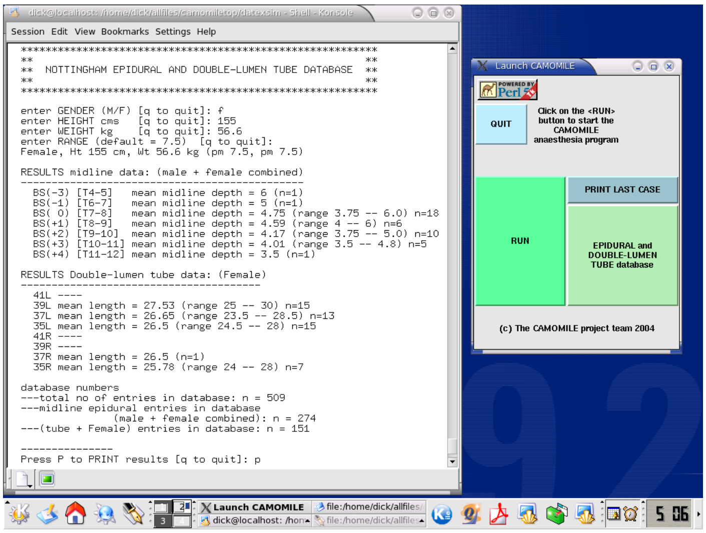
Nottingham City Hospital
NHS Trust

Patient label

Begin Log at 2 35:15

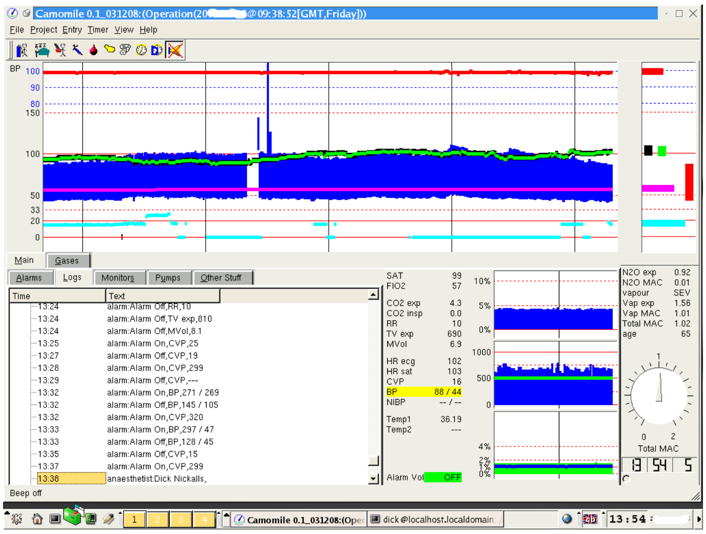
```
Note (192): opened logfile "/home/dick/allfiles/camomiletop/theatredata/                /base.log"
2004-04-29,  12:35:45   Patient:  57 yrs, 65 kg, 173 cm, Male
2004-04-29,  12:35:52   Surgeon:  Mr
2004-04-29,  12:35:58   Anæsthetist:  Dr
2004-04-29,  12:57:21   Drug:  Atracurium 20
2004-04-29,  13:00:24   Drug:  Metariminol .5mg
2004-04-29,  13:17:20   Comment:  {Temp = 36.6C (naso-pharyngeal)
2004-04-29,  13:20:14   Comment:  {MAC-age=1.2
2004-04-29,  13:20:59   Comment:  {Epidural 10 mls Bupivicaine + fentanyl IN
2004-04-29,  13:23:23   Comment:  {CVP=9
2004-04-29,  13:25:15   Urine output:  45 total
2004-04-29,  13:55:37   Comment:  {Start of thoracotomy
2004-04-29,  15:04:09   Drug:  Noradrenaline (2mg/50 mls) 6 mls/hr (since 30 mins ago)
2004-04-29,  15:06:06   Drug:  Gelofusin 1500 IN
2004-04-29,  15:06:21   Drug:  Hartmans solution 1000 set UP
2004-04-29,  15:06:50   Comment:  {Temp = 37.2C
2004-04-29,  15:08:47   Comment:  {wash out
2004-04-29,  15:35:04   Comment:  {end of surgery
2004-04-29,  15:36:22   Drug:  Atracurium 30
2004-04-29,  15:50:49   Comment:  {moving on to bed
2004-04-29,  15:53:10   Comment:  {changing ett to single lumen
2004-04-29,  15:55:33   Drug:  Propofol 20
```

Figure 1.7: Anaesthetic record — drug record


dick@localhost: /home/dick/allfiles/camomiletop/datexsim - Shell - Konsole
Session Edit View Bookmarks Settings Help
Launch CAMOMILE
QUIT
Click on the <RUN> button to start the CAMOMILE anaesthesia program
PRINT LAST CASE
RUN
EPIDURAL and DOUBLE-LUMEN TUBE database
(c) The CAMOMILE project team 2004
Launch CAMOMILE
file:/home/dick/allfiles
dick@localhost: /hom
file:/home/dick/allfile
5 06

```
************************************************************
**                                                        **
**  NOTTINGHAM EPIDURAL AND DOUBLE-LUMEN TUBE DATABASE    **
**                                                        **
************************************************************

enter GENDER (M/F) [q to quit]: f
enter HEIGHT cms   [q to quit]: 155
enter WEIGHT kg    [q to quit]: 56.6
enter RANGE (default = 7.5)  [q to quit]:
Female, Ht 155 cm, Wt 56.6 kg (pm 7.5, pm 7.5)

RESULTS midline data: (male + female combined)
----------------------------------------------
  BS(-3) [T4-5]   mean midline depth = 6 (n=1)
  BS(-1) [T6-7]   mean midline depth = 5 (n=1)
  BS( 0) [T7-8]   mean midline depth = 4.75 (range 3.75 -- 6.0) n=18
  BS(+1) [T8-9]   mean midline depth = 4.59 (range 4 -- 6) n=6
  BS(+2) [T9-10]  mean midline depth = 4.17 (range 3.75 -- 5.0) n=10
  BS(+3) [T10-11] mean midline depth = 4.01 (range 3.5 -- 4.8) n=5
  BS(+4) [T11-12] mean midline depth = 3.5 (n=1)

RESULTS Double-lumen tube data: (Female)
----------------------------------------
  41L ----
  39L mean length = 27.53 (range 25 -- 30) n=15
  37L mean length = 26.65 (range 23.5 -- 28.5) n=13
  35L mean length = 26.5 (range 24.5 -- 28) n=15
  41R ----
  39R ----
  37R mean length = 26.5 (n=1)
  35R mean length = 25.78 (range 24 -- 28) n=7

database numbers
---total no of entries in database: n = 509
---midline epidural entries in database
               (male + female combined): n = 274
---(tube + Female) entries in database: n = 151

---------------
Press P to PRINT results [q to quit]: p
```

Figure 1.8: Screen showing the initial graphic front-end (right) which allows the user to either start the program, or access other utilities. For example, clicking on the `<epidural>` button runs the Epidural and Double-lumen tube database program (shown on the left of the screen) which predicts epidural depth and tube length for a given height and weight.



Camomile 0.1_031208:(Operation(20[redacted]@09:38:52[GMT,Friday]))

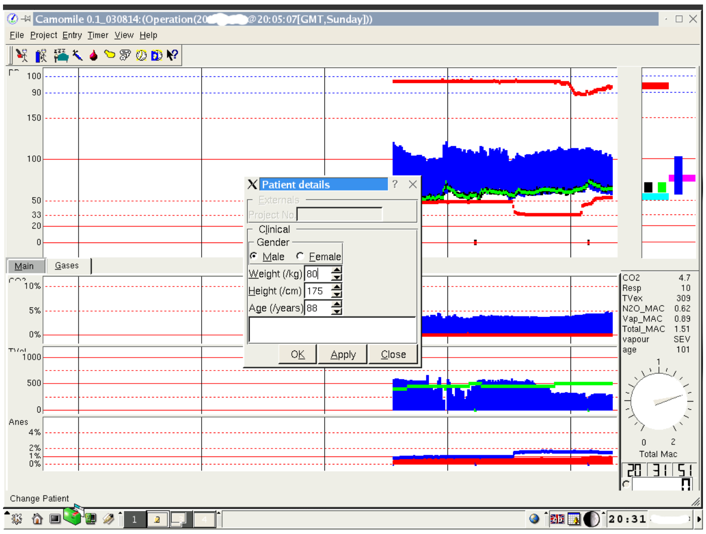
Time	Text
13:24	alarm:Alarm Off,RR,10
13:24	alarm:Alarm Off,TV exp,810
13:24	alarm:Alarm Off,MVol,8.1
13:25	alarm:Alarm On,CVP,25
13:27	alarm:Alarm Off,CVP,19
13:28	alarm:Alarm On,CVP,299
13:29	alarm:Alarm Off,CVP,---
13:32	alarm:Alarm On,BP,271 / 269
13:32	alarm:Alarm Off,BP,145 / 105
13:32	alarm:Alarm On,CVP,320
13:33	alarm:Alarm On,BP,297 / 47
13:33	alarm:Alarm Off,BP,128 / 45
13:35	alarm:Alarm Off,CVP,15
13:37	alarm:Alarm On,CVP,299
13:38	anaesthetist:Dick Nickalls,

SAT	99
FIO2	57
CO2 exp	4.3
CO2 insp	0.0
RR	10
TV exp	690
MVol	6.9
HR ecg	102
HR sat	103
CVP	16
BP	88 / 44
NIBP	-- / --
Temp1	36.19
Temp2	---
Alarm Vol	OFF

N2O exp	0.92
N2O MAC	0.01
vapour	SEV
Vap exp	1.56
Vap MAC	1.01
Total MAC	1.02
age	65

Beep off

Figure 1.9: Screen showing the log, alarm, MAC and trend windows. The blood pressure (BP) is highlighted in yellow in the alarms window, indicating a minor departure from the 'normal' range.



Camomile 0.1_030814:(Operation(20[redacted]@20:05:07[GMT,Sunday]))

Patient details

Externals

Project No.

Clinical

Gender

● Male ○ Female

Weight (/kg) 80

Height (/cm) 175

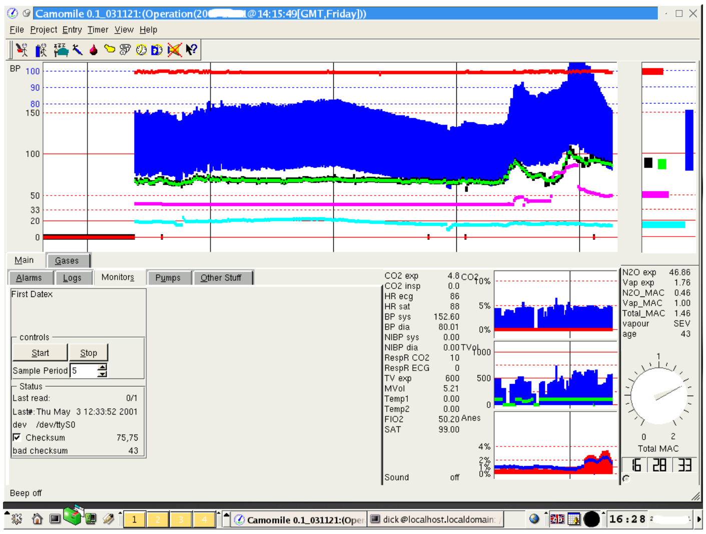
Age (/years) 88

OK Apply Close

CO2	4.7
Resp	10
TVex	309
N2O_MAC	0.62
Vap_MAC	0.89
Total_MAC	1.51
vapour	SEV
age	101

Change Patient

Figure 1.10: Screen showing use of the Patient Data widget


Camomile 0.1_031121:(Operation(20[redacted]@14:15:49[GMT,Friday]))
File Project Entry Timer View Help
BP
100
90
80
150
100
50
33
20
0
Main
Gases
Alarms
Logs
Monitors
Pumps
Other Stuff
CO2
10%
5%
0%
TVol
1000
500
0
Anes
4%
2%
1%
0%
1
0
2
Total MAC
16 28 33
Beep off
1 2 3 4
Camomile 0.1_031121:(Oper
dick@localhost.localdomain:
16:28

First Datex

controls

Start Stop

Sample Period 5

Status

Last read: 0/1

Last#: Thu May 3 12:33:52 2001

dev /dev/ttyS0

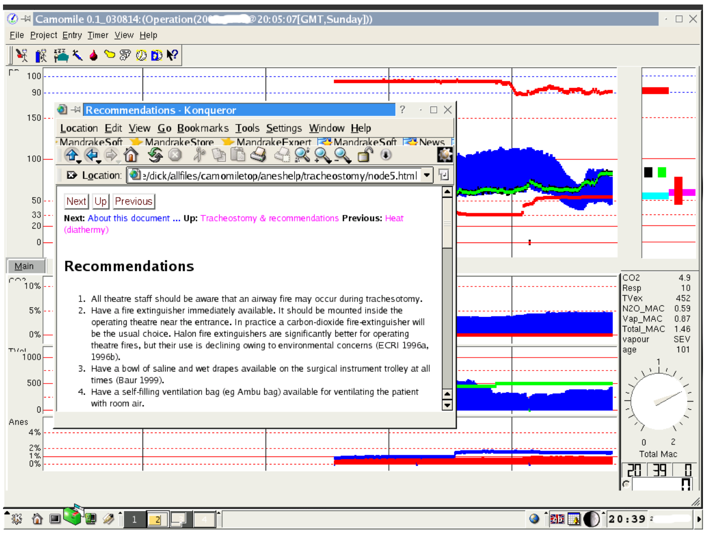
☑ Checksum 75,75

bad checksum 43

```
CO2 exp      4.8
CO2 insp     0.0
HR ecg       86
HR sat       88
BP sys       152.60
BP dia       80.01
NIBP sys     0.00
NIBP dia     0.00
RespR CO2    10
RespR ECG    0
TV exp       600
MVol         5.21
Temp1        0.00
Temp2        0.00
FIO2         50.20
SAT          99.00

Sound        off
```

```
N2O exp      46.86
Vap exp      1.76
N2O_MAC      0.46
Vap_MAC      1.00
Total_MAC    1.46
vapour       SEV
age          43
```

Figure 1.11: Screen showing the Datex controller (bottom left of screen)


Camomile 0.1_030814:(Operation(20[redacted]@20:05:07[GMT,Sunday]))
File Project Entry Timer View Help
100
90
150
100
50
33
20
0
Main
10%
5%
0%
1000
500
0
Anes
4%
2%
1%
0%
Recommendations - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
MandrakeSoft MandrakeStore MandrakeExpert MandrakeSoft News
Location:
Next Up Previous
1
0
2
Total Mac
20 39 0
1 2
20:39

Location: e/dick/allfiles/camomiletop/aneshelp/tracheostomy/node5.html

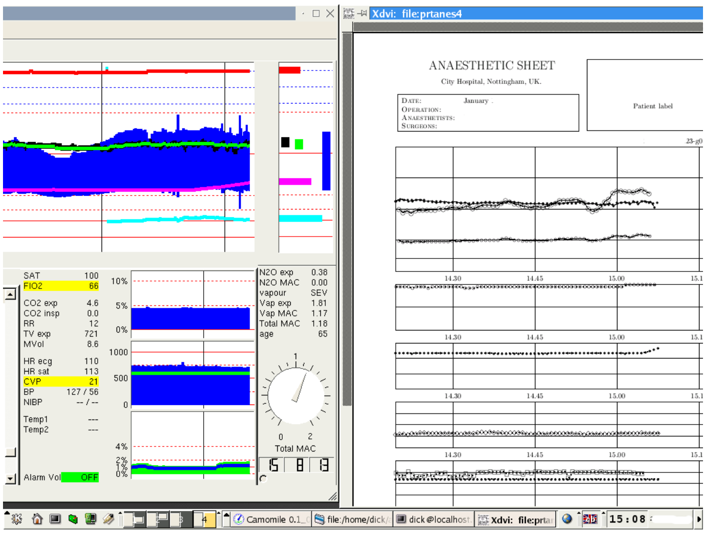
Next: About this document ... **Up:** Tracheostomy & recommendations **Previous:** Heat (diathermy)

Recommendations

1. All theatre staff should be aware that an airway fire may occur during trachesotomy.
2. Have a fire extinguisher immediately available. It should be mounted inside the operating theatre near the entrance. In practice a carbon-dioxide fire-extinguisher will be the usual choice. Halon fire extinguishers are significantly better for operating theatre fires, but their use is declining owing to environmental concerns (ECRI 1996a, 1996b).
3. Have a bowl of saline and wet drapes available on the surgical instrument trolley at all times (Baur 1999).
4. Have a self-filling ventilation bag (eg Ambu bag) available for ventilating the patient with room air.

```
CO2          4.9
Resp         10
TVex         452
N2O_MAC      0.59
Vap_MAC      0.87
Total_MAC    1.46
vapour       SEV
age          101
```

Figure 1.12: Screen showing showing a 'help' file viewed using the KDE web browser



SAT 100
FIO2 66

CO2 exp 4.6
CO2 insp 0.0
RR 12
TV exp 721
MVol 8.6

HR ecg 110
HR sat 113
CVP 21
BP 127 / 56
NIBP -- / --

Temp1 ---
Temp2 ---

Alarm Vol OFF

N2O exp 0.38
N2O MAC 0.00
vapour SEV
Vap exp 1.81
Vap MAC 1.17
Total MAC 1.18
age 65

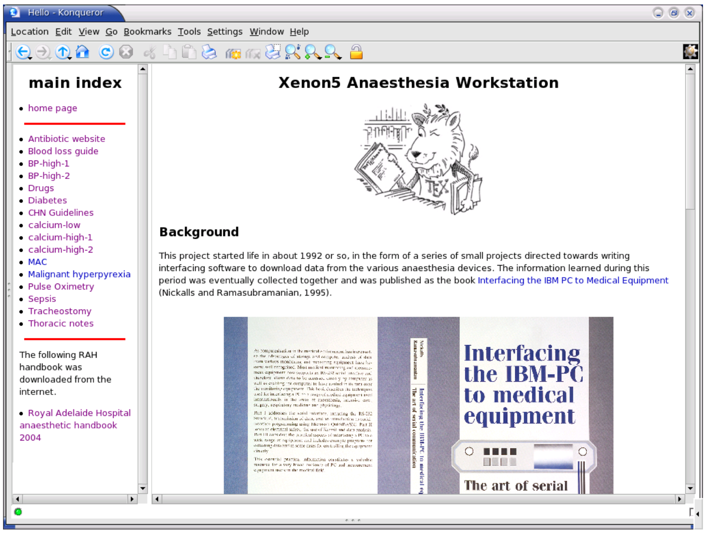
ANAESTHETIC SHEET

City Hospital, Nottingham, UK.

DATE: January
OPERATION:
ANAESTHETISTS:
SURGEONS:

Patient label

Figure 1.13: Screen showing real-time data plus preview of printout



Hello - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
Interfacing the IBM-PC to medical equipment
The art of serial

main index

- home page

- Antibiotic website
- Blood loss guide
- BP-high-1
- BP-high-2
- Drugs
- Diabetes
- CHN Guidelines
- calcium-low
- calcium-high-1
- calcium-high-2
- MAC
- Malignant hyperpyrexia
- Pulse Oximetry
- Sepsis
- Tracheostomy
- Thoracic notes

The following RAH handbook was downloaded from the internet.

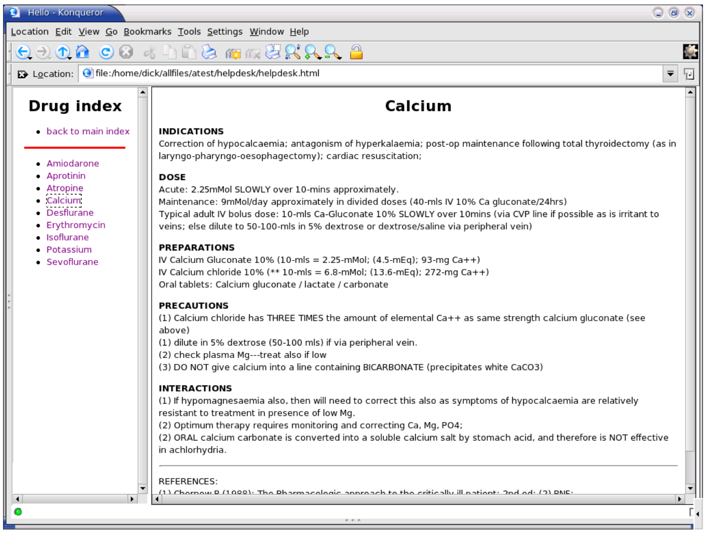
- Royal Adelaide Hospital anaesthetic handbook 2004

Xenon5 Anaesthesia Workstation

Background

This project started life in about 1992 or so, in the form of a series of small projects directed towards writing interfacing software to download data from the various anaesthesia devices. The information learned during this period was eventually collected together and was published as the book Interfacing the IBM PC to Medical Equipment (Nickalls and Ramasubramanian, 1995).

Figure 1.14: Screen showing help desk home page.


Hello - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
Location: file:/home/dick/allfiles/atest/helpdesk/helpdesk.html

Drug index

- back to main index

- Amiodarone
- Aprotinin
- Atropine
- Calcium
- Desflurane
- Erythromycin
- Isoflurane
- Potassium
- Sevoflurane

Calcium

INDICATIONS
Correction of hypocalcaemia; antagonism of hyperkalaemia; post-op maintenance following total thyroidectomy (as in laryngo-pharyngo-oesophagectomy); cardiac resuscitation;

DOSE
Acute: 2.25mMol SLOWLY over 10-mins approximately.
Maintenance: 9mMol/day approximately in divided doses (40-mls IV 10% Ca gluconate/24hrs)
Typical adult IV bolus dose: 10-mls Ca-Gluconate 10% SLOWLY over 10mins (via CVP line if possible as is irritant to veins; else dilute to 50-100-mls in 5% dextrose or dextrose/saline via peripheral vein)

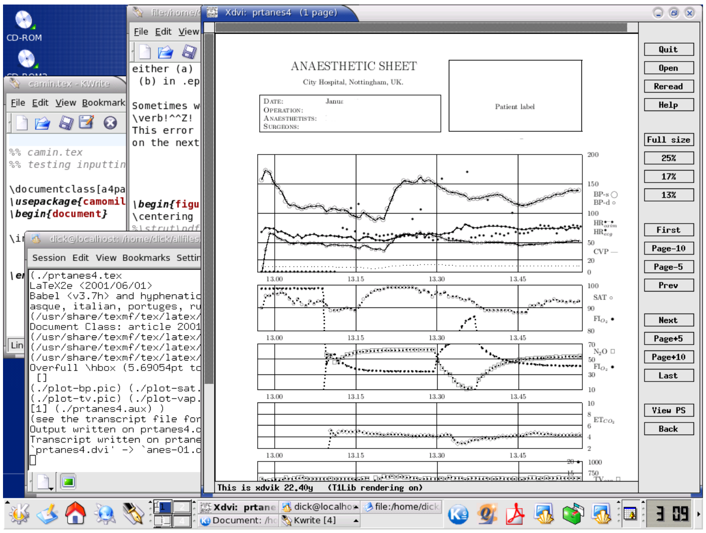
PREPARATIONS
IV Calcium Gluconate 10% (10-mls = 2.25-mMol; (4.5-mEq); 93-mg Ca++)
IV Calcium chloride 10% (** 10-mls = 6.8-mMol; (13.6-mEq); 272-mg Ca++)
Oral tablets: Calcium gluconate / lactate / carbonate

PRECAUTIONS
(1) Calcium chloride has THREE TIMES the amount of elemental Ca++ as same strength calcium gluconate (see above)
(1) dilute in 5% dextrose (50-100 mls) if via peripheral vein.
(2) check plasma Mg---treat also if low
(3) DO NOT give calcium into a line containing BICARBONATE (precipitates white CaCO3)

INTERACTIONS
(1) If hypomagnesaemia also, then will need to correct this also as symptoms of hypocalcaemia are relatively resistant to treatment in presence of low Mg.
(2) Optimum therapy requires monitoring and correcting Ca, Mg, PO4;
(2) ORAL calcium carbonate is converted into a soluble calcium salt by stomach acid, and therefore is NOT effective in achlorhydria.

REFERENCES:
(1) Chernow B (1988): The Pharmacologic approach to the critically ill patient; 2nd ed; (2) BNF;

Figure 1.15: Help desk showing the drug info for Calcium.



```
%% camin.tex
%% testing inputtin

\documentclass[a4pa
\usepackage{camomil
\begin{document}

\i

\e
```

```
either (a)
 (b) in .ep

Sometimes w
\verb!^^Z!
This error
on the next

\begin{figu
\centering
%\strut\pdf
```

```
(./prtanes4.tex
LaTeX2e <2001/06/01>
Babel <v3.7h> and hyphenatic
asque, italian, portuges, ru
(/usr/share/texmf/tex/latex/
Document Class: article 2001
(/usr/share/texmf/tex/latex/
(/usr/share/texmf/tex/latex/
(/usr/share/texmf/tex/latex/
Overfull \hbox (5.69054pt to
 []
(./plot-bp.pic) (./plot-sat.
(./plot-tv.pic) (./plot-vap.
[1] (./prtanes4.aux) )
(see the transcript file for
Output written on prtanes4.d
Transcript written on prtane
`prtanes4.dvi' -> `anes-01.d
```

This is xdvik 22.40y (T1Lib rendering on)

Figure 1.16: Screen showing preview of the Anaesthetic Record about to be printed

Chapter 2

Data processing in anaesthesia

ch-camhist

2.1 Introduction

The next significant change in anaesthesia practice will very likely be related to data processing, particularly in the areas of smart alarms and decision support. While development and take-up in the operating theatre is almost imperceptible just now, the future surely lies in computers offering anaesthetists seriously useful facilities and real-time information. The initial motivation with regard to data handling lay in automating the anaesthesia record. However, while this technology has been effectively solved for over 15 years (see Kenny 1990), the take-up by anaesthestists remains almost zero.

2.2 History of the anaesthesia record

The documentation of events, procedures undertaken, physiological parameters (*vital signs*) which are associated with the process of anaesthesia (for example, in conjunction with surgery or an intensive care setting) is known as the Anaesthesia Record. This record serves two main functions, namely (a) medical (the moment-to-moment drug history and vital-signs serves as a useful practical aid), and (b) medico-legal (the anaesthesia record is a legal document in its own right, setting out the facts as they unfold during an anaesthetic).

2.2.1 Background

Effective surgical anaesthesia was established in 1846 following the discovery of the effects of inhaled diethyl-ether ("*ether*"). Although John Snow (1813–1858), Joseph Clover (1825–1882), and Mounier (1855) demonstrated the importance of monitoring the pulse and respiration during anaesthesia (Ellis, 1995; Rushman, Davies and Atkinson, 1996) it was not until 1894, at the Massachusetts General Hospital, Boston, that surgeons Ernst A Codman (1869–1940) and Harvey Cushing (1869–1939) established the practice of keeping a careful *written* record (on graph paper) of the patient's pulse and respiration rate during operations—known as the 'ether chart' (Beecher, 1940; Hirsch and Smith, 1986). Apparently this was prompted by a death under anaesthesia in 1893 (Rushman, Davies and Atkinson 1996, p 128). In 1901 they started including measurements of the arterial blood pressure using the newly described apparatus of Scipione Riva-Rocci (1863–1937) of Turin (Cushing 1902; Cushing 1903; Rushman, Davies and Atkinson, 1996, p 157).

Ralph Waters (1936; 1942) championed and emphasised the importance of written anaesthetic records, and later Noseworthy (1945) produced special cards on which to record anaesthetic details (see Rushman, Davies and Atkinson (1996), p 111, for an illustration).

2.2.2 Automation

The first mechanical device capable of printing an anaesthetic record was the *Nargraf* machine of 1930 developed by EI McKessons (Westhorpe 1989), which generated a semi-automated record of inspired oxygen, tidal volume and inspiratory gas pressure.

Since then little of real technological significance was developed in the area of anaesthesia monitoring until the 1970s, when advances in chip technology gave rise to clinically useful portable electronic devices for measuring such things as arterial and central venous blood pressure, breath-by-breath concentrations of oxygen, carbon dioxide and inhalational anaesthetics, pulse oximetry, and of course, small computers.

From an interfacing point of view, a very significant and far reaching feature was incorporated into virtually all early medical monitoring devices, namely a specialised serial communications interface known as the RS-232 port. Equally significant, therefore, was the decision by IBM to incorporate the same RS-232 port into the IBM Personal Computer which appeared in 1981. Fortunately all IBM-compatible PCs since then have also incorporated the RS-232 serial port.

Owing to the wisespread use of the RS-232 interface in medical equipment it soon became a relatively easy matter to use a PC to access the numerous measured parameters output by patient monitoring devices, and consequently anaesthetists increasingly explored methods for automating data collection and processing, with a view to developing useful trend displays of measured data, real-time calculation of derived parameters, and hard-copy data printouts.

The RS-232 interface is set to be replaced in the relatively near future by the Medical Interface Bus (MIB; IEEE-1073). This a high-tech high-speed medical plug-and-play version of the familiar domestic USB interface, and will greatly facilitate medical device inter-connectivity, largely by allowing the relevant interface software to be more easily standardised.

An automated anaesthesia record is significantly superior to the usual hand-written record, since it samples data more frequently and more accurately, and hence it has significant medico-legal advantages regarding the documentation of patient care, particularly during complicated and/or unstable cases.

2.2.3 Guidelines

The Royal College of Anaesthetists has published a summary of what data ought to be collected (in addition to the electronic data from the anaesthesia monitors) as part of the Anaesthesia Record (Adams 1996), building on the work of Lack *et al.* (1994). The extent to which these guidelines are actually being met has also been looked at (Smith, 1997). The required record set which appears to be emerging, consists of a number of fields within the following general categories: pre-, per- and post-operative information, untoward events and hazard flags.

2.3 The anaesthesia workstation

Much work has gone into studying the anaesthetists's workload (Weinger *et al.* 1997; Byrne, Sellen and Jones 1998; Leedal and Smith 2005), and it is clear that computerisation would free anaesthetists and nurses from much of the work of documentation (e.g. drug doses, procedures, measured parameters etc.), releasing significant amounts of time which could be better spent on direct patient care and vigilance. Anaesthesia/ITU information and record-keeping systems clearly offer the advantage of allowing the anaesthetists and nursing staff to concentrate fully on the patient, leading to enhanced vigilance and improved patient care and safety.

For example, Kennedy *et al.* (1976) showed that anaesthetists commonly spend 10–15% of their time producing the handwritten record. Similarly, Smith (1997) pointed out that about 10% of the anaesthetists' time was related to record keeping, and that if this were to increase then this would likely be to the patient's detriment. A similar study by Wong *et al.* (2003) showed that an ICU information system reduced the time spent by nurses on documentation by 31%, with the significant benefit being that almost half of the time saved was transferred to patient assessment and direct patient care.

Secondary data processing by anaesthetists in the UK is well behind other countries in this regard, with electronic data collection being actively supported by foreign health organisations. For example, in 2001 a special newsletter issue of the Anesthesia Patient Safety Foundation (APSF) was devoted to *Information systems in anaesthesia* (APSF, 2001). In 2002 the APSF formally endorsed the use of automated anesthesia information management systems (AIMS) as the following quote indicates (see also `www.gasnet.org/societies/apsf/`).

> In this context it is heartening that the ... APSF has recently endorsed the use of automated anesthesia information management systems (AIMS): "The Anesthesia Patient Safety Foundation endorses and advocates the use of automated record keeping in the perioperative period and the subsequent retrieval and analysis of that data to improve patient safety."
>
> Gage, 2002.

Anaesthetists urgently need to harness the power of computing technology in a way which can help them both in the operating theatre and in the clinic, most likely via some form of anaesthesia workstation. While such systems will probably be commercial, this is not necessarily the only route. Providing anaesthetists take some interest in the details, it not impossible to imagine useful systems being developed along the Open Source model (cf. the immensely successful Linux operating system).

The emphasis for such a workstation needs to be on helping the anaesthetist give a safe anaesthetic during difficult circumstances. It would access data from various sources via the Medical Interface Bus (e.g. anaesthesia monitors, HIS) and then process the data in various ways; for example, data storage, making the anaesthesia record, smart alarms, decision support, data export, emergency communications. It is important that such workstations are developed separately from the commercial anaesthesia monitors and anaesthesia machines, rather than being integrated with them.

Even at a basic level computers in the operating theatre already offer significant advantages over and above creating good anaesthesia records. For a long time now it has been relatively straight forward to access data from anaesthesia monitors (Nickalls and Ramasubranian 1995; Nickalls 1998) and display warnings, information and value-added parameters; for example, real-time age-corrected MAC (Nickalls and Mapleson, 2003).

Of course commercial information and anaesthesia record systems are available (e.g. the NarKoData system (IMESO, GmbH, Huttenberg, Germany)—see Benson *et al.* 2000), but they are generally far from ideal. For example, these systems tend to be extremely expensive and are generally machine specific (e.g. the Datex AS/3 system), and are quite awkward to use. The existing commercial systems tend to be most useful in collecting what one might loosely call 'hospital/theatre management' information, while being relatively unhelpful in facilitating anaesthesia-related activities, or even generating good quality records. These latter failings largely account for the poor take-up of commercial systems by anaesthetists.

Computerisation also offers a significant research benefit. For example, in a study by Muller *et al.* (2002) anaesthetists were able to search the database of their automated anaesthesia record-keeper and establish useful risk factors predictive of subsequent inotropic support requirement following cardio-pulmonary bypass.

2.3.1 Databases

Extracting data from big databases requires a good data dictionary (Sanderson and Monk 2003) as, for example, the currently well advanced SNOMED Clinical Terms program (SNOMED-CT) (http://www.snomed.org/snomedct/), which is a dynamic health care terminology infrastructure being developed as part of the NHS National Program for Information Technology (NPfIT). A demonstration program can be accessed from the SNOMED-CT home page.

Another NPfIT dictionary database of interest to anaesthetists is the Dictionary of Medicines and Devices (DM+d) (http://www.dmd.nhs.uk/). This consists of a number of coordinated XML-encoded pharmaceutical-related databases, which also incorporate the associated SNOMED encoding. Of particular interest to anaesthetists is the Virtual Therapeutic Moiety (VTM) database of approximately 2000 official drug names which are to be used henceforth in all computer interactions relating to drugs. This list is updated weekly and can be downloaded from the website (password required). This list is currently incorporated into the experimental program used in the thoracic theatre.

2.3.2 The future

The future holds the exciting prospect of developing sophisticated (and possibly Open Source) anaesthesia workstations giving anaesthetists access to good data displays and trends, sophisticated alarms (smart-alarms), real-time (and predictive) modelling for drugs and physiological parameters, information management and decision-support systems (Sanderson, Watson and Russell 2005). A good overview of what might be possible (in a USA office setting) was presented recently by Gage (2002).

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Chapter 3

TEX in the Operating Theatre: an Anaesthesia application.

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Abstract

This article describes the author's experience of using TEX for typesetting the *Anaesthesia Record* as part of an automated data-collection system developed for use in the operating theatre.

TUGboat; 19(3), Proceedings of the 19th International TEX Users Group meeting, Toruń, Poland, August 17–20, 1998; pp. 7–9.
`http://www.tug.org/TUGboat/Articles/tb19-3/tb60nick.pdf`

Introduction

Since the theme of this year's conference is "*Integrating TEX with the surrounding world*" I would like to describe my integration of TEX with the world of the operating theatre—specifically with the domain of anaesthesia.

One of the many things that occupies anaesthetists during an operation is documentation. This takes the form of a log of various physiological parameters (see Figure 1), drugs used, blood lost, fluids administered, procedures performed etc., otherwise known as the *Anaesthesia Record*. Since this is generally a handwritten record, the documentation side of things can become rather neglected during busy periods, and consequently, anaesthetists are increasingly using computers to automate the collection of such data. This has many advantages including allowing real-time processing of data, generation of various derived parameters, and greatly enhanced information display facilities.

Collecting and processing the data

Since most monitoring equipment used in Critical Care environments has an RS-232 serial interface the process of data-collection, construction of trend graphics, formatting and typesetting can be automated reasonably easily.

My own system is a menu-driven research application which uses compiled QuickBASIC programs to coordinate the access, display and printing of both real-time physiological data and keyboard inputs. The printing module uses LATEX to typeset the text and graphics to create the *Anaesthesia Record* in a format suited to the hospital notes.

The data from the various anaesthesia monitors is accessed via the serial port using a multiplexing device. Individual parameters are then extracted using the relevant software for each of the various monitors—see [1] for interfacing details relating to particular anaesthesia monitors. Unfortunately there is currently no standardisation with regard to data formats for medical monitoring devices, but this may well soon change with the development of the new international Medical Information Bus (MIB) standard (IEEE 1073).

During anaesthesia the program accesses and displays all the data in real-time as graphic trends, as well as deriving a number of so-called 'value-added' parameters and processing keyboard entries. At the end of the operation the program typesets the text and graphics to form the *Anaesthesia Record*.

The graphics are created using the excellent *freeware* program GNUPLOT[1] which allows batch processing and will output graphics in LATEX picture format.

Armed with the maximum and minimum values for each of the measured parameters, the program writes the GNUPLOT input files, and then calls GNUPLOT, outputting the graphics in LATEX picture format, and placing them into the appropriate directories. The program then writes the LATEX input `.tex` file, and then calls LATEX to typeset the text and graphics. Finally the `.dvi` file is printed and put into the hospital notes. In practice all this is performed locally within the operating theatre, such that the *Anaesthesia Record* is printed and placed in the patient notes just as the patient is returned to the recovery area. Figure 1 shows the graphics page of a typical *Anaesthesia Record*.

Advantages of ASCII-based systems

The fact that both TEX and GNUPLOT use inputs which are ASCII-based has the great advantage that their input files can be written on-the-fly by the coordinating computer program. Such flexibility allows the final text and graphics of the document to be tailored to the data. For example, this allows the axes of graphs to be automatically adjusted depending on maximum and minimum values. Similarly, text layout can be made to vary depending on the particular keyboard entries made during the operation.

Small is beautiful

An automated system for data collection, display and printing has clear advantages over the usual hand-written method; it is certainly a more accurate record, and physiological data can be sampled much more frequently. Furthermore, keyboard entry of drugs and other information can be made simple and fast by careful design of the interface.

Since this is a specific stand-alone application, it is possible to use a much cut-down version of LATEX consisting only of the essential files, fonts and style options required for the application, with the effect that the size of the printing module can be made extremely small. A not insignificant bonus, therefore, of using TEX as the typesetting engine is that I am able to make use of old 386 PCs having relatively small hard-drives, which have been discarded by my memory-hungry colleagues!

References

1. Nickalls RWD and Ramasubramanian R (1995). *Interfacing the IBM-PC to medical equipment; the art of serial communication.* Cambridge University Press, Cambridge, UK. pp 402. ISBN: 0 521 46280 0

[1] `http://www.cs.dartmouth.edu/gnuplot_info.html`

ANAESTHETIC SHEET

Theatre 1, City Hospital, Nottingham, UK.

DATE:	18 August 2000
OPERATION:	Laparotomy
ANAESTHETISTS:	RWD Nickalls *et al.*
SURGEONS:	AN Other *et al.*

JOHN DOE
dob 24/01/1925
Hosp No: 123456789
Nightingale Ward

Age: 75

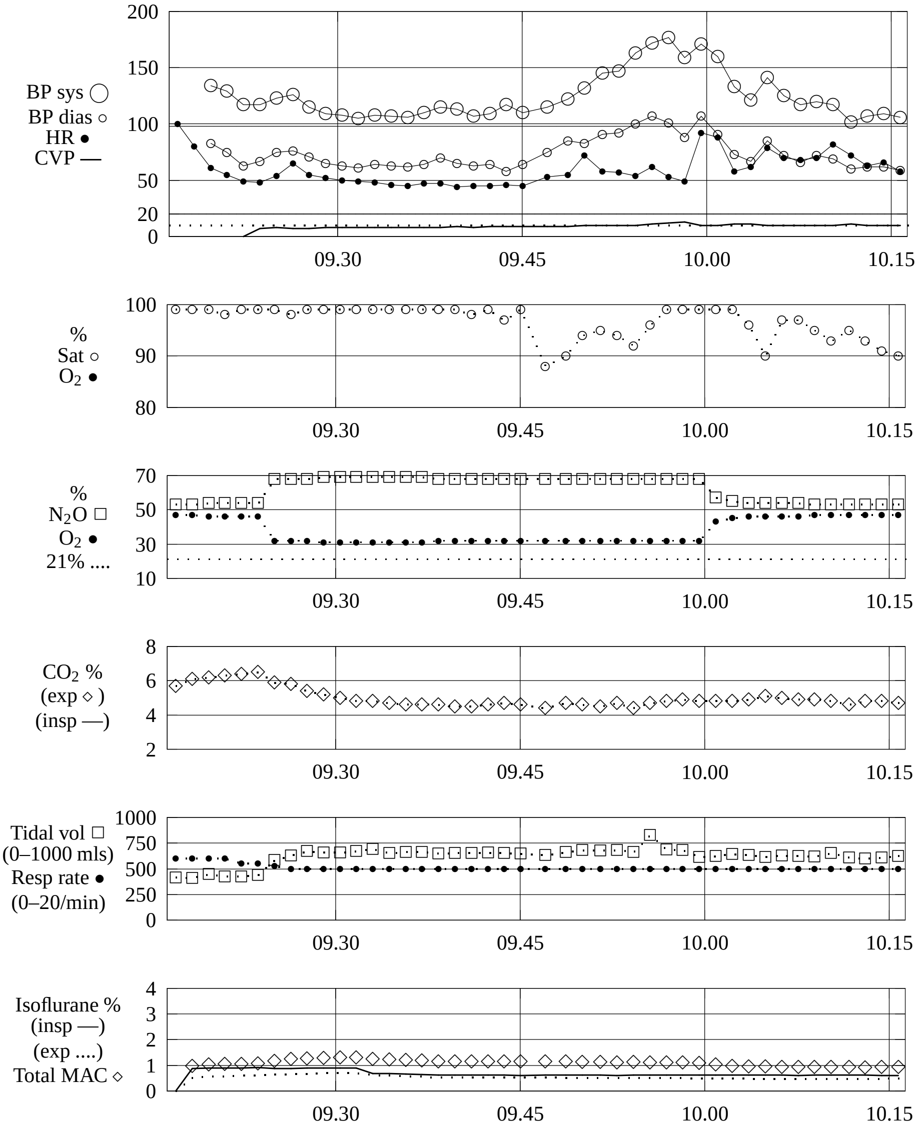


Figure 3.1: Example of the graphics section of a typical *Anaesthesia Record*. The six graphs are output by GNUPLOT in LATEX picture format. The record shows blood pressure (BP), heart rate (HR), central venous pressure (CVP), oxygen saturation of haemoglobin (Sat), inspired oxygen (O_2), inspired nitrous oxide (N_2O), expired carbon dioxide (CO_2), tidal volume, respiration rate, isoflurane and MAC.

Chapter 4

The Datex AS/3 anaesthesia monitor

ch-dxmon.tex

4.1 Introduction

The Datex-Ohmeda[1] AS/3 and CS/3 monitors are versatile modular anaesthesia monitoring systems, which have an asynchronous serial interface for data acquisition. The various modules access a comprehenensive range of physiological parameters. Note that the technical latest manual regarding the serial interface is *AS/3 and CS/3 Monitor Product specification—computer information. v.3.4* March 1999 (G-version update by Rene Coffeng, 23/Nov/1998).

The electrical safety Type classifications of the various Applied Parts (e.g. NIBP cuff, temperature probe) are shown in Table 4.1.

Table 4.1: Applied Parts and their Types.

Applied Part	Type
ECG	CF
NIBP	BF
Invasive BP/CVP/PA	CF
Temperature probe	CF
Cardiac output	?

[1] Datex-Ohmeda Division, Instrumentarium Corp., P. O. Box 900, FIN-00031 Datex-Engstrom, Finland. Tel: +358–9–39411; FAX: +358–9–146–3310.
Datex-Ohmeda, 71, Great North Road, Hatfield, Hertfordshire, AL9-5EN, UK; Tel: 01707-263-570, FAX 01707-260-065.

4.1.1 Software version

Software is frequently revised, and different monitors may have different software versions. The software version is displayed on the screen when the monitor is switched on, and is also indicated as a 1-byte code (the 5^{th} byte) in the 40-byte 'header' which precedes all data output via the serial port. The 1-byte software version codes are shown in Table 4.2.

Table 4.2: Software versions and their *Datex Read Interface* codes (`r_dri_level`).

Software version	code
S-STD93	0
S-STD94, S-ARK94	1
S-STD95, S-ARK95, S-STD96, S-ARK96	2
S-ANE97, S-ARK97, S-ICU97	3

4.1.2 Available software

A program for PCs called COLLECT.EXE, which saves data from the Datex AS/3 monitor, is available from Datex. This program is known as the *AS/3 PC Data Collection Software*. The program collects the data-strings output by the monitor and saves them to the hard disk of the PC either as an ASCII file, a binary file, or in a form compatible with LOTUS 1-2-3. The package consistes of three program files as follows.

COLLECT.EXE
COLLECT.CFR (used for storing setup information)
AUTOFILE.CFR (used for writing an automatic date-dependent filename

4.2 Serial port

The monitors have a male 9-pin D-type serial port which conforms to the RS-232-E standard. The serial port is located at the back of the monitor.

The serial port allows commands to be sent to the monitor, and also allows CTS/RTS flow control (hardware handshaking) via pins 7 and 8 of the serial port.

Table 4.3: Datex AS/3 & CS/3 RS-232 serial port.

Pin No.	Name	Comments
2	RxD	Receives data
3	TxD	Transmits data (LOW on power-up)
5	GND	Signal ground
7	RTS	Set HIGH when powered up
8	CTS	Can be used to control data flow

4.2.1 Cable connections

The wiring configuration for interfacing the Datex AS/3 monitor to a PC is shown in Figure 4.1.

- **CTS** [NB: not fully checked out for AS/3] Data output from the Datex monitor is usually controlled by influencing the voltage status of the Datex-AS3 CTS line. Data output is enabled only if its CTS is held HIGH (positive). [BUT in my experience data output was only stopped by setting the datex RTS line LOW !!]

  However, if it is necessary to use hardware handshaking to control data output, then it is probably best to connect the Datex monitor's CTS line to the computer's RTS line, which can then be used to control data output by setting the status of the computer's RTS line HIGH or LOW as necessary (see Section 5.16 in *Nickalls & Ramasubramanian, 1995*).

- **RTS** The Datex-AS3's RTS line is held HIGH on power up. Holding the Datex RTS line LOW will stop all data output until it is pulled HIGH again.

  Consequently it is usual to connect this line to the computer's CTS line, to enable the computer program to control data output from the Datex monitor.

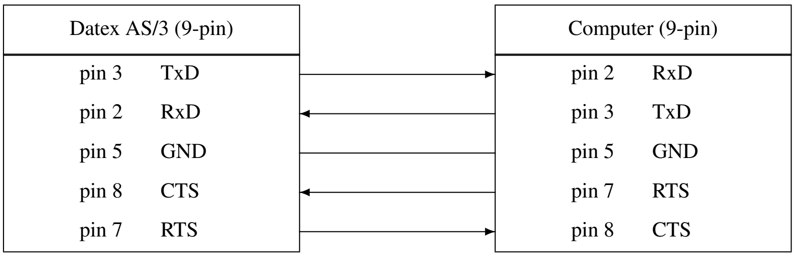


Figure 4.1: Wiring configuration for the Datex AS/3 & CS/3 monitors.

4.2.2 Protocol

The serial protocol is shown in Table 4.4. Note that this protocol is slightly unusual in that it uses an 11-bit character-frame (1 start-bit, 8 data-bits, EVEN parity-bit, 1 stop-bit). Consequently some older software which uses a ten-bit character frame (e.g. QuickBASIC 4.5, QBASIC 1.1) cannot be used to program the Datex-AS3 serial interface. PowerBASIC 3.5, FirstBASIC (PB1.0) and VisualBASIC can all handle 11-bit character-frames. Note that the recent 3.15 version of KERMIT (1998) also accomodates the 11-bit character frame (see the `SET PARITY HARDWARE` command), and so can be used to access data from the Datex AS/3 monitor.

4.3 Command format

The monitor is able to output data in a number of modes; either (a) only the current displayed measurement values; (b) values averaged over the last 10 seconds, (c) values averaged over the last 60 seconds. See the Datex manual for full details.

Table 4.4: Serial protocol for the Datex AS/3 & CS/3 monitors.

Bit rate	19200
Start bits	1
Data bits	8
Parity	Even
Stop bits	1

Unfortunately the AS/3 and CS/3 monitors use a rather complicated and somewhat confusing 'transmission request' command (a string of 52 bytes) to instruct the monitor to output data (the complete output data-string is 321 bytes). The frequency of data output (every 10 seconds, 60 seconds etc) is set using bytes 43 and 44. In practice we require data output every 10 seconds, for which is encoded using byte 43 → `0Ahex`, and byte 44 → `00hex` (see below).

The Transmission Request string which is the one currently used is described below. In practice it is assembled by the `SUB requeststring` (page **??**), which is part of the Datex module (Chapter **??**, page **??**). This string is sent only once (by the Main module) soon after system initialisation, as shown in the following code extract from the Main Module (Chapter **??**, page **??**), which sends the string and then waits a maximum of 5 seconds for the first incomming data-string before timing-out.

```
...
REM now trigger data output (every 10 sec) from Datex AS/3 monitor
CALL RequestString    :REM in DatexAS3 module
REM  start timer and wait max 5 sec for data to arrive
thistime=timer
DO
  IF TIMER > thistime + 5 then
     PRINT
     BEEP
     PRINT " No data --- quiting program"
     SLEEP 1
     END
  END IF
  REM if data in buffer, then continue
  IF LOC(datexAS3comportfilenumber%) > 0 then
     PRINT " data output OK"
     SLEEP 1
     EXIT DO
  END IF
  SLEEP 1
  REM print dots ... while waiting
  PRINT ".";
LOOP
...
```

4.3.1 Transmission request command

The structure of the Transmission request command-string used in this project is that of type-2 (see the correspondence at the end of this chapter), and triggers data-outout every 10 seconds. The following few points are relevant here.

- The string starts and ends with a `7Eh` byte).
- I have numbered the bytes (decimal) starting with 1 (1–52)
- The byte values are given in Hexadecimal (h) and Decimal (d).
- The bytes are divided up into their functional groups (1, 2 4 bytes etc)
- The following string is the one currently used and assembled by the `SUB requeststring` (page **??**), which is part of the Datex module (Chapter **??**, page **??**)—see above.

```
 Byte   Hex     Decimal   Description
 no     value   value
 ====================================
 1     7E      126    Start flag
 -----------------------------------
 2     31      49     (start of header)
 3     00       0     Total length = 0031h = 49d bytes (word r_len)
 ------------------------------
 4     00       0     Reserved, set to zero (byte res1)
 ----------------------------
 5     00       0     Ignored by monitor, set to zero (byte r_dri_level)
 ----------------------------
 6     00       0     Reserved = 0000H  (byte res2[2])
 7     00       0
 ----------------------------
 8     00       0     Transmission time = 0x00000000, ignored by monitor
 9     00       0     when sending transmission request (dword r_time).
10     00       0     However, time can be meaningful in outputted
11     00       0     messages, which use the header of the same
                       structure (dword r_time).
-------------------------------
12     00       0      Reserved = 00000000H (dword res3)
13     00       0
14     00       0
15     00       0
-------------------------------
16     00       0      Main type of record = DRI_MT_PHDB = 0
17     00       0      (r_maintype)
-------------------------------
18     00       0      Offset to the first subrecord = 0000H
19     00       0      (sr_desc[0].offset)
-------------------------------
20     00       0      Type of first subrecord, DRI_PH_XMIT_REQ = 0
                       (sr_desc[0].sr_type)
```

```
-------------------------------
21     00       0      Offset to the second subrecord = 0000H,
22     00       0      calculated from the
                       beginning of the data area after the header part.
                       Value is not meaningful, since there is only one
                       subrecord in the request (sr_desc[1].offset).
-------------------------------
23     FF     255     "No more subrecords" (sr_desc[1].sr_type)
-------------------------------
24       0x00
25       0x00      sr_desc[2].offset = 0x0000, no meaning since only
                      one subrecord transmitted...
26       0x00      sr_desc[2].sr_type, no meaning
------------------------
27       0x00
28       0x00      sr_desc[3].offset = 0x0000, no meaning
29       0x00      sr_desc[3].sr_type, no meaning
------------------------
30       0x00
31       0x00      sr_desc[4].offset = 0x0000, no meaning
32       0x00      sr_desc[4].sr_type, no meaning
-----------------------
33       0x00
34       0x00      sr_desc[5].offset = 0x0000, no meaning
35       0x00      sr_desc[5].sr_type, no meaning
-----------------------
36       0x00
37       0x00      sr_desc[6].offset = 0x0000, no meaning
38       0x00      sr_desc[6].sr_type, no meaning
-----------------------
39       0x00
40       0x00      sr_desc[7].offset = 0x0000, no meaning
41       0x00      sr_desc[7].sr_type = 0x00, no meaning
------------------------------------------
START OF THE TRANSMISSION REQUEST SUBGROUP
42       0x01      Request current values of physiological database
                    = DRI_PH_DISPL (field phdb_rcrd_type of struct
                      phdb_req)
------------------------
43       0x0A
44       0x00      Transmission interval in seconds = 0x000A, i.e.,
                     send current values of physiological database every
                     10 seconds (field tx_interval of struct phdb_req).
------------------------
45       0x00
46       0x00      reserved[0] of struct phdb_req, must be zeroed
-----------------------
47       0x00
48       0x00      reserved[1] of struct phdb_req, must be zeroed
-----------------------
```

```
49      0x00
50      0x00      reserved[2] of struct phdb_req, must be zeroed
----------------------------
51      0x3B      checksum
----------------------------
52      0x7E      End flag
----------------------------
```

In the Data Program, this command string is send by the `SUB RequestString` (page **??**), which is part of the Datex module detailed in Chapter **??** (see also Figure **??**, page **??**).

4.4 Output data-string format

The data format for the Datex AS/3 & CS/3 monitors is described in the Datex document *AS/3 & CS/3 Computer Interface Specification, Revision 3.1, 15/5/1997*. This is a 37-page A4 document available as a WORD document from Datex, and covers the software versions listed in Table 4.2.

After the computer sends the above Transmission Request command-string, the Datex AS/3 monitor responds by outputting the following 321-byte string every 10 seconds, which consists of

(a) a 1-byte 'start' flag `<7Eh>`,
(b) a 40-byte 'header',
(c) a number of so-called 'sub-records', and finally
(d) a checksum (1 byte) followed by a 1-byte 'stop flag' `<7Eh>`.

The following few points are relevant.

- The string starts and ends with a `7Eh` byte = 126d.

- I have numbered the bytes (decimal) starting with 1 (1–321). Note that byte-1 is the FIRST byte to be received by the PC.

- The byte values are given in Hexadecimal (h)

- In the following listing the bytes are divided up into their functional groups (1, 2, 3, 4 bytes etc). Note that the order of the bytes within a group is shown in the left-hand column.

- When decoding the groups of bytes, note that UNIX rules apply, and the within-group byte-order needs to be 'reversed' (i.e. in order to have the highest byte number to the left-hand side, and lowest byte number to the right-hand side). For example, the four-byte double-word group `<CBh><CFh><F2h><33h>` (bytes 8–11) encodes for the time in seconds since 1970.00 yrs. Reversing the the byte order (i.e. having bit-0 on the right-hand side) gives the double-word `<33F2CFCBh>` which is 871550923 seconds → 10087 days → 27 July, 1997.

- Each funtional grouping (what Datex calles a 'sub-record') has a group of status-bytes (usually 4 bytes) and a group of label-bytes (usually two bytes). These status and label bytes are mostly bit-encoded to indicate such things as the source of the particular measurement, or the existance of an error state etc—some of the encodings for the more important parameters are included in this list, but it is not comprehensive just now (see manual for full details).

```
---------------------
1      <7E>        Start Flag
--------------------
START OF HEADER
2,3    <3E> <01>   Total no of bytes in transmission
                   <01h><3eh> = 318d = 318 bytes (header + data)
                   Total bytes=321= 1 start + 318 + 1checksum + 1 stop
--------------------
4      <94>
5      <03>        Interface version supported by device (0-3)
                   see version code Table

6      <00>
7      <00>
8-11   <CB> <CF> <F2> <33>   Time in secs since 1970.00 yrs
                             = <33><f2><cf><cb>=871550923 secs
                             = 10087 days= 27yrs 7 months 22 days
                             = 27 July 1997
12-15  <00> <00> <00> <00>
16-17  <00> <00>
18-20  <00> <00> <01>    The <1> here is sr_type for output data (1-4, p 10)
21-23  <BD> <BD> <ff>    ?? the <ff> indicating no more subrecords??
24-26  <BD> <BD> <BD>    ?? why are these fields filled with <BD> ????
27-29  <BD> <BD> <BD>    Note <bdh> = 189d
30-32  <BD> <BD> <BD>
33-35  <BD> <BD> <BD>
36-38  <BD> <BD> <BD>
39-41  <BD> <BD> <BD>
------end of header, always  40 bytes------------

-----start of the data area-------------------------
42-45  <CB> <CF> <F2> <33>   Time in secs since 1/1/1970 = 8.7155092 E08
----------------
       ECG subrecord
46-49  <0B> <3A> <00> <00>   ECG group header (status- 4 bytes)
50-51  <74> <32>                              (label - 2 bytes)
52-53  <02> <80>       HR
54-55  <0A> <81>       st1 (mm/100)
56-57  <05> <81>       st2
58-59  <08> <81>       st3
60-61  <01> <80>       rr  (resp rate/min)
--------------
       INV Press(1) subrecord
62-65  <1> <0> <0> <0>   Inv Press 1 header (status)
66-67  <1> <0>                              (label)
68-69  <2> <80>      sys     x100
70-71  <2> <80>      diast   x100
72-73  <2> <80>      mean    x100
74-75  <1> <80>      heart rate/min
```

```
--------------
       INV Press(2) subrecord
76-79  <1> <0> <0> <0>   status
80-81  <2> <0>           label
82-83  <2> <80>          sys      x100
84-85  <2> <80>          diast    x100
86-87  <2> <80>          mean     x100
88-89  <1> <80>          heart rate/min
---------------
        INV Press(3) subrecord
90-93   <1> <0> <0> <0>  status
94-95   <B> <0>          label
96-97   <2> <80>         sys       x100
98-99   <2> <80>         diast     x100
100-101 <2> <80>         mean      x100
102-103 <1> <80>         heart rate/min
----------------
        INV Press(4) subrecord
104-107 <1> <0> <0> <0>  status
108-109 <3> <0>          label
110-111 <2> <80>         sys       x100
112-113 <2> <80>         diast     x100
114-115 <2> <80>         mean      x100
116-117 <1> <80>         heart rate/min
-------------------
        NIBP subrecord
118-121 <3> <0> <0> <0>   status
122-123 <3> <1>           label (bit-8 --> 1 after 60 secs)
124-125 <1> <80>   sys       x100
126-127 <1> <80>   diast     x100
128-129 <1> <80>   mean      x100
130-131 <1> <80>   HR        /min
-------------------
        Temp (1)  subrecord
132-135 <3> <0> <0> <0>    status
136-137 <B> <0>            label
138-139 <1> <80>           deg C x100
------------------
        Temp (2)  subrecord
140-143 <3> <0> <0> <0>    status
144-145 <C> <0>            label
146-147 <1> <80>           deg C x100
------------------
        Temp (3)  subrecord
148-151 <0> <0> <0> <0>    status
152-153 <D> <0>            label
154-155 <1> <80>           deg C x100
------------------
        Temp (4)  subrecord
156-159 <0> <0> <0> <0>    status
```

```
160-161 <E> <0>            label
162-163 <1> <80>           deg C x100
------------------
        Saturation (SpO2)  subrecord
164-167 <3> <0> <0> <0>  status
168-169 <0> <0>          label(00=SaO2 01=SvO2 10=error)
170-171 <1> <80>     (SAT% * 100)
172-173 <1> <80>     HR
174-175 <2> <80>     IR-amp (infra red amplitude)
176-177 <1> <80>     label for SaO2 = 1 /SvO2 = 2 /SO2= 0 / 3 not used
------------------
        Carbon dioxide (CO2)  subrecord
178-181 <47> <0> <0> <0>  status
182-183 <1> <0>           label ( source: 01=CO2 10=ECG)
184-185 <1> <80>    ET (% x100)
186-187 <1> <80>    FI (% x100)
188-189 <1> <80>    RR
190-191 <28> <1D>   amb_P (x10 mmHg ambient pressure)
 ------------------
        Oxygen (O2) subrecord
192-195 <3> <0> <0> <0>  status
196-197 <0> <0>          label
198-199 <1> <80>  ET O2  (% x100)
200-201 <1> <80>  FI O2  (% x100)
---------------------
        Nitrous Oxide (N2O) subrecord
202-205 <3> <0> <0> <0>     status
206-207 <0> <0>             label
208-209 <1> <80>     ET N2O (% x100)
210-211 <1> <80>     FI N2O (% x100)
---------------------
        Anaesthetic agent
212-215 <3> <0> <0> <0>     status
216-217 <2> <0>             label
218-219 <1> <80>     ET AA (% x100)
220-221 <1> <80>     FI AA (% x100)
222-223 <0> <0>      MAC sum (x100)
----------------------
        Flow & Volume
224-227 <3> <0> <0> <0>  status
228-229 <0> <0>          label
230-231 <0> <0>          RR  (resp rate)
232-233 <1> <80>         pPeak      x100
234-235 <1> <80>         peep       x100
236-237 <1> <80>         pPlat      x100
238-239 <1> <80>         TV-insp    x10
240-241 <1> <80>         TV-exp     x10
242-243 <1> <80>         compliance x100 cms H2O
244-245 <1> <80>         MV exp     x100/min
-----------------
```

```
        Cardiac Output & Wedge press
246-249 <3> <0> <0> <0>  status
250-251 <7> <0>          label
252-253 <1> <80>         CO
254-255 <1> <80>         Blood Temp
256-257 <1> <80>         Ref
258-259 <1> <80>         pcwp
----------------------
        Neuro-Muscular J (NMJ)
260-263 <20> <0> <0> <0>  status
264-265 <0> <0>           label
266-267 <1> <80>
268-269 <1> <80>
270-271 <FF> <8d>
-----------------
        ECG (2)  (no header)
272-273 <2> <80>
274-275 <1> <80>
276-277 <1> <80>
-----------------------
        Reserved-1 (8 bytes)
278-285 <0> <0> <0> <0> <D3> <0> <1> <80>
------------
        Invas Press (5) subrecord
286-289 <0> <0> <0> <0>
290-291 <D> <0>
292-293 <2> <80>
294-295 <2> <80>
296-297 <2> <80>
298-299 <1> <80>
--------
        Invas Press (6) subrecord
300-303 <0> <0> <0> <0>
304-305 <E> <0>
306-307 <2> <80>
308-309 <2> <80>
310-311 <2> <80>
312-313 <1> <80>
------------------
        Reserved-2 (2 bytes)
314-315 <0> <0>
------------------
    Marker Byte
316 <0>
----------------
    Reserved-3 (1 byte)
317 <0>
-----------------
        Last WORD
318-319 <31> <0>         (2 --> 319 = 318 bytes)
```

```
------------------
320 <B9>    checksum
-------------------
321 <7E>    stop Flag
 ---------------------------- end of transmission-------------
```

4.5 Example of data output

The following Datex AS/3 output data-string was received during an operation and saved in D-data (decimal), and is the same as that shown in Chapter 14, page 183. For details of the format of the D-data see page 183.

```
....
....
AS300,09:36:49,05-03-1991,(m/d/y) Datex AS/3 monitor
AS301,126,062,001,111,005,000,000,166,052,241,058,000,000,000,000,000,000,000
AS302,000,001,000,074,255,097,220,044,000,000,000,044,000,000,000,189,189,032
AS303,000,189,189,032,000,166,052,241,058,019,048,000,000,000,034,067,000,021
AS304,000,001,128,001,128,001,128,003,000,000,000,001,000,062,058,231,028,049
...
...
AS316,141,001,128,067,000,066,000,000,000,000,000,189,189,001,128,000,000,000
AS317,000,013,000,002,128,002,128,002,128,001,128,000,000,000,000,014,000,002
AS318,128,002,128,002,128,001,128,000,000,000,064,081,000,222,126
```

One of the Datex AS/3 invasive blood pressure 'sub-records' is encoded in bytes 62–75, as shown in the following Table.

Table 4.5: Decoding invasive blood pressure 1 (bytes 62–75). The systolic, diastolic and mean blood pressure values ×100 are encoded as Hex words (Unix). The decimal value therefore has to be divided by 100 to obtain the physiological value, and in this particular case the decoded values are: systolic BP 149.1, diastolic BP 73.99, mean BP 105.45. In practice we would only pass on the integer values for blood pressure.

	mean	diastolic	systolic
Byte number	73 72	71 70	69 68
Hex values	29h 31h	1Ch E7h	3Ah 3Eh
Hex word	2931h	1CE7h	3A3Eh
decimal	10545	7399	14910
BP = decimal/100	105.45	73.99	149.1

The following is the same data but placed in byte order (1–321), together with the Dec and Hex equivalent.

```
    byte,Hex,Dec
     -----------
```

```
001,7E,126
002,3E,062
003,01,001
004,6F,111
005,05,005
006,00,000
007,00,000
008,A6,166
009,34,052
010,F1,241
011,3A,058
012,00,000
013,00,000
014,00,000
015,00,000
016,00,000
017,00,000
018,00,000
019,00,000
020,01,001
021,00,000
022,4A,074
023,FF,255
024,61,097
025,DC,220
026,2C,044
027,00,000
028,00,000
029,00,000
030,2C,044
031,00,000
032,00,000
033,00,000
034,BD,189
035,BD,189
036,20,032
037,00,000
038,BD,189
039,BD,189
040,20,032
041,00,000
042,A6,166
043,34,052
044,F1,241
045,3A,058
046,13,019
047,30,048
048,00,000
049,00,000
050,00,000
```

```
051,22,034
052,43,067
053,00,000
054,15,021
055,00,000
056,01,001
057,80,128
058,01,001
059,80,128
060,01,001
061,80,128
062,03,003
063,00,000
064,00,000
065,00,000
066,01,001
067,00,000
068,3E,062
069,3A,058
070,E7,231
071,1C,028
072,31,049
073,29,041
074,43,067
075,00,000
076,03,003
077,00,000
078,00,000
079,00,000
080,02,002
081,00,000
082,F7,247
083,08,008
084,F4,244
085,05,005
086,2C,044
087,07,007
088,43,067
089,00,000
090,00,000
091,00,000
092,00,000
093,00,000
094,0B,011
095,00,000
096,02,002
097,80,128
098,02,002
099,80,128
100,02,002
```

```
101,80,128
102,01,001
103,80,128
104,00,000
105,00,000
106,00,000
107,00,000
108,03,003
109,00,000
110,02,002
111,80,128
112,02,002
113,80,128
114,02,002
115,80,128
116,01,001
117,80,128
118,03,003
119,00,000
120,00,000
121,00,000
122,03,003
123,01,001
124,01,001
125,80,128
126,01,001
127,80,128
128,01,001
129,80,128
130,01,001
131,80,128
132,03,003
133,00,000
134,00,000
135,00,000
136,0B,011
137,00,000
138,D2,210
139,0D,013
140,03,003
141,00,000
142,00,000
143,00,000
144,0C,012
145,00,000
146,04,004
147,80,128
148,00,000
149,00,000
150,00,000
```

```
151,00,000
152,0D,013
153,00,000
154,01,001
155,80,128
156,00,000
157,00,000
158,00,000
159,00,000
160,0E,014
161,00,000
162,01,001
163,80,128
164,03,003
165,00,000
166,00,000
167,00,000
168,00,000
169,00,000
170,DE,222
171,26,038
172,44,068
173,00,000
174,6C,108
175,00,000
176,01,001
177,80,128
178,03,003
179,00,000
180,00,000
181,00,000
182,09,009
183,00,000
184,8A,138
185,01,001
186,00,000
187,00,000
188,0C,012
189,00,000
190,66,102
191,1D,029
192,03,003
193,00,000
194,00,000
195,00,000
196,00,000
197,00,000
198,71,113
199,0E,014
200,A5,165
```

```
201,0F,015
202,03,003
203,00,000
204,00,000
205,00,000
206,00,000
207,00,000
208,07,007
209,17,023
210,F1,241
211,16,022
212,03,003
213,00,000
214,00,000
215,00,000
216,04,004
217,00,000
218,00,000
219,00,000
220,00,000
221,00,000
222,3A,058
223,00,000
224,03,003
225,00,000
226,00,000
227,00,000
228,00,000
229,00,000
230,0C,012
231,00,000
232,0A,010
233,0F,015
234,08,008
235,02,002
236,C0,192
237,0D,013
238,82,130
239,16,022
240,E5,229
241,14,020
242,F4,244
243,06,006
244,7E,126
245,02,002
246,00,000
247,00,000
248,00,000
249,00,000
250,07,007
```

```
251,00,000
252,01,001
253,80,128
254,01,001
255,80,128
256,01,001
257,80,128
258,01,001
259,80,128
260,20,032
261,00,000
262,00,000
263,00,000
264,00,000
265,00,000
266,01,001
267,80,128
268,01,001
269,80,128
270,FF,255
271,8D,141
272,01,001
273,80,128
274,43,067
275,00,000
276,42,066
277,00,000
278,00,000
279,00,000
280,00,000
281,00,000
282,BD,189
283,BD,189
284,01,001
285,80,128
286,00,000
287,00,000
288,00,000
289,00,000
290,0D,013
291,00,000
292,02,002
293,80,128
294,02,002
295,80,128
296,02,002
297,80,128
298,01,001
299,80,128
300,00,000
```

```
301,00,000
302,00,000
303,00,000
304,0E,014
305,00,000
306,02,002
307,80,128
308,02,002
309,80,128
310,02,002
311,80,128
312,01,001
313,80,128
314,00,000
315,00,000
316,00,000
317,40,064
318,51,081
319,00,000
320,DE,222
321,7E,126
----------
```

4.6 Correspondence

```
...

The subrecord types are intended to be used in the sr_type field of the
sr_desc -struct:s (see section 3.2, page 8 of the specification) and 0
(=DRI_PH_XMIT_REQ) is the correct value for that field. However, the
phdb_rcrd_type field in the data structure "struct phdb_req" is used
for a different purpose, though the used enumeration is the same.

The phdb_rcrd_type field indicates what kind of physiological data you
are requesting, for example:

sr_type = 0, phdb_rcrd_type = 1    => Send current values of the
                                      physiological database.

sr_type = 0, phdb_rcrd_type = 2    => Send 10 s trended values

sr_type = 0, phdb_rcrd_type = 3    => Send 60 s trended values
sr_type = 0, phdb_rcrd_type = 4    => Send auxiliary phys. information

values 1, 2, 3 and 4 for field sr_type are reserved for output values,
as you suggested.

So DRI_PH_DISPL = 1, DRI_PH_10S_TREND = 2, DRI_PH_60S_TREND = 3 and
DRI_PH_AUX_INFO = 4. The values correspond to subrecord type listed on
```

page 10 of the specification, although the constant names are not explicitly defined in the table.

In addition, the texts in the "Value" field of the table on page 11 of the specification (related to tx_interval) are incorrect: Instead of texts "Any positive value together with subrecord type ..." the texts should be "Any positive value together with physiological record type ..." referencing to field phdb_rcrd_type of struct phdb_req rather than to the sr_type field of struct sr_desc.

... the tx_interval field specifies the transmission interval for the physiological data records, the type of which is specified by the field phdb_rcrd_type ("... together with subrecord type ..."). For 10s and 60s trends the transmission interval is, however, always fixed (10s and 60s). In addition, the special values -1 and 0 have special side effects as documented in the table on page 11 of the specification.

Chapter 5

Interfacing the serial port in Linux

ch-serialport

5.1 Introduction

Currently using the Perl programs as3sim.pl and dn-getfile2.pl. Both in the dir ~/aHOUSE/perl/serial-port/serial-port-code/testing/

5.2 Device::SerialPort.pm

This is a Perl program which allows control of the serial port in Linux. I originally used version 1.002_000, and have needed to modify it by adding a new CTS subroutine in order to allow hardware handshaking control via the CTS line. This was done simply by copying and modifying the existing sub rts_active subroutine.

These are the working subroutines in the 1.002 version (no change with the 1.04 version).

```
sub rts_active {
    return unless (@_ == 2);
    my $self = shift;
    return unless ($self->can_rts());
    my $on = yes_true( shift );
    # returns ioctl result
    my $value=$IOCTL_VALUE_RTS;
    my $rc=$self->ioctl($on ? ’TIOCMBIS’ : ’TIOCMBIC’, \$value);
    #my $rc=ioctl($self->{HANDLE}, $on ? $bitset : $bitclear, $rtsout);
    warn "rts_active($on) ioctl: $!\n" if (!$rc);
    return $rc;
}

sub cts_active { ## RWDN  Jan 2 / 2006
    return unless (@_ == 2);
    my $self = shift;
    ### return unless ($self->can_cts());
    my $on = yes_true( shift );
    # returns ioctl result
    my $value=$IOCTL_VALUE_CTS;
    my $rc=$self->ioctl($on ? 'TIOCMBIS' : 'TIOCMBIC', \$value);
    #my $rc=ioctl($self->{HANDLE}, $on ? $bitset : $bitclear, $rtsout);
    warn "cts_active($on) ioctl: $!\n" if (!$rc);
    return $rc;
}
```

The current version is `Device-SerialPort-1.04.tar.gz` available from CPAN. When the module is installed, linux (Mandriva) places the module in the following location.
`/usr/lib/perl5/site_perl/5.8.7/i386-linux/Device/SerialPort.pm`

5.3 Sending program (`as3sim.pl`)

```
#! perl
##-----------------
# sends data out
##------------------
# AS3sim.pl  sends data  (from dxdemo3c.pl)
# RWD Nickalls Nov 27, 2005
use Device::SerialPort  qw(:STAT);  # for MS_RTS_ON functions etc
#use POSIX;
use strict;
use warnings;
use Fatal;
use Carp;
use IO::Handle;     ## for autoflush() page 224-226
## use prompt module
## use commandline stuff
##------------------------------
my $COM1 = "/dev/ttyS0";
my $ob = Device::SerialPort->new ($COM1) || croak "Can't open COM1: $!";
##---------------------------
$ob->error_msg(1); # use built-in error messages
$ob->user_msg(1);
#----------------
## setup the COM port
$ob->baudrate(19200) || croak "fail setting baudrate"; ## 19200
$ob->parity("none") || croak "fail setting parity";
$ob->databits(8)  || croak "fail setting databits";
$ob->stopbits(1)  || croak "fail setting stopbits";
$ob->handshake("none")  || croak "fail setting handshake";
$ob->write_settings || croak "no settings";
##-------------------------------
#---------------------
my $pass;
```

```
## use a while{} loop to  send output data via  the serial port

##--------test pulses--
## works OK
#print "testing RTS on/off\n";
# $ob->pulse_rts_on(1000); # 100 ms
# $ob->pulse_rts_off(1000);

#-------------testing--------
#if (MS_RTS_ON() == 1){print "RTS-ON\n"}
#    else {print "RTS-OFF\n"};

#if (MS_CTS_ON() ==0){print "CTS-ON\n"}
#    else {print "CTS-OFF\n"};

my $rtsval=0;
$rtsval = MS_RTS_ON();
print "RTSval = ",$rtsval,"\n";

my $ctsval=0;
$ctsval = MS_CTS_ON();
print "CTSval = ",$ctsval,"\n";

my $ringval=0;
$ringval = MS_RING_ON();
print "RIval = ",$ringval,"\n";

#$ob->dtr_active('F'); # 0=red, 1=green OK
#$ob->rts_active(0); # 0=red, 1=green   OK

sleep 2;
#---------------

#----------------------
## send the file
sendfile();
goto LASTLINE;
#----------------------

my $crlf="\r\n";
my $outstring1="abcdefg12345".$crlf;
my $outstring2="***123***".$crlf;
## write the strings to the port

while (1) {
            print $outstring1;
            $pass=$ob->write($outstring1);
            sleep 3;
            print $outstring2;
            $pass=$ob->write($outstring2);
            sleep 3
          }

LASTLINE:
close ; # close any open files
$ob->close || croak "can't close SERIAL PORT";
undef $ob; ## returns memory back to Perl


##----SUB----------------------
## to send a file line by line

sub sendfile{
    ## works OK
    ## always send EOF character to signify the end
    my $ifile = "./drugs.txt";
    local *outfile;  ## make it local if in SUB (best practices p=?)

    if (-e $ifile) {
          open (*outfile, '<', $ifile)||croak "ERROR: can't open file $ifile\n";
                  };

      ## now read each line in the file, and place parameters into an array
      print "...reading the fields file < $ifile > line-by-line\n";
      my $dataline;
      my $outstring;
      my $Len; # length of string
      my $total_len=0;

        LINE:
        while (<outfile>){
        #  next LINE if /^#/;  #skip # comments
        #  next LINE if /^%/;  #skip % comments
        # next LINE if /^$/;  #skip blank lines
        #----------
        # grab the whole line as a string
      $dataline = $_;
      $outstring = $dataline;
      # determine the Byte size of the file
      $Len=length $outstring;  $total_len=$total_len + $Len;
      ##chomp($dataline); # remove the line-ending
      print $outstring;
            $pass=$ob->write($outstring);
       ## need a small delay to work properly  - why exactly
       for (my $j=1;$j<15000;$j++){}; ## seems to be OK
       };
     ## now send EOF character ASCII(26) = ^Z
      my $EOF=chr 26;
            $pass=$ob->write($EOF);
            for (my $j=1;$j<15000;$j++){}; ## seems to be OK
      print "\n----end of file-----\n";
      print "total length of file = ", $total_len, "\n";
      print "waiting 5 secs before closing the file\n";
      sleep 5; # ? include slight pause here before closing the file
      close (*outfile); # need to keep the *
         };
```

5.4 Receiving program (dn-getfile2.pl)

```
#! perl
##--------------
# receives data file
##---------------
# dn-getfile.pl (from dxdemo3c.pl)
## (receives a file & prints to the log file)
# RWD Nickalls Dec 31, 2005

use Device::SerialPort qw( :STAT);
use strict;
use warnings;
use Fatal;
use Carp;
use IO::Handle;     ## for autoflush() page 224-226
## use prompt module
## use commandline stuff

my $pass;  ## used when writing output to the port ?
#-----------------------
my $COM2 = "/dev/ttyS1";
my $ob = Device::SerialPort->new ($COM2) || croak "Can't open COM2: $!";
##-------------------------
open my $LOG,  ">", "logfile.log" ||croak "can't open logfile  file \n";
## see book p 224-226 for better autoflush using  IO::Handle module
## force autoflush after every write/print
$LOG->autoflush();     # to the log file
*STDOUT->autoflush();  # to the screen
print {$LOG} "The logfile is open OK\n";
## print some heading time/date info to the log file
my $timenow=localtime();
print {$LOG} "the time is:- ",$timenow, "\n";
##-----------------------------------
$ob->error_msg(1); # use built-in error messages
$ob->user_msg(1);
#--------------------
## setup the COM port
$ob->baudrate(19200) || croak "fail setting baudrate"; # 19200
$ob->parity("none") || croak "fail setting parity";
$ob->databits(8) || croak "fail setting databits";
$ob->stopbits(1) || croak "fail setting stopbits";
```

```
$ob->handshake("none") || croak "fail setting handshake";
$ob->write_settings || croak "no settings";
##----------------------------
my $dump;
my $portbuffer="";
my $Ld;
my $Lb;
##------------------------------------------
##  flush out the buffer before collecting data

# $ob->lookclear; ## flush buffers
# goto JUMP;
print "\n-----flushing the buffer-- \n";
print  {$LOG} "\n-----flushing the buffer-- \n";
while  (($portbuffer=$ob->input) ne "") {
            $dump=$dump.$portbuffer;
            $Lb=length $portbuffer;
            $Ld=length $dump;
            print  {$LOG}  "UART buffer length = ", $Lb,"  ", "software-buffer length = ", $Ld,"\n
         };
JUMP:
   print  {$LOG} "\n-----*flush done-- \n";
   print  {$LOG} "\n===starting collecting data====\n";
#--------------------------
my $EOF=chr 26; # EOF character
my $Leof = -1;
my $Lcr; # char length to the CR
my $buffer=""; ## the string buffer
my $data="";
my $sumpb=0;
## use a while{} loop to read the input data from the serial port
##my $crlf="\r\n";
my $lf="\n";

my $j=0;
INPUT:
while (1) {
      print "waiting for data.....<CTRL-C> to quit\n";
      print " total chars =                         ",$sumpb, "\n";
      while (($portbuffer=$ob->input) ne "") {
               $buffer.=$portbuffer;  # ie $buffer=$buffer.$portbuffer;
               $Lcr= index ($buffer, $lf);  ## length to next LF
               $Leof= index ($buffer, $EOF);  ## detect EOF character
               $sumpb=$sumpb+ (length $portbuffer);
                     if  ($Lcr > -1) {
                          # detects LF character and prints line
                          $data= substr($buffer, 0, $Lcr);
                          print {$LOG}  $data,"\n";
                          $buffer = substr($buffer, $Lcr + 1  ); ## +1 remove the LF as well as CR
                     #     print {$LOG} "remaining buffer =", $buffer,"\n";
                     #    print {$LOG} "total portbuffer chars = ", $sumpb,"\n";
                     #    print {$LOG} "---------------\n";
                          }
                   elsif  ($Leof > -1){
                          ## detects EOF char and prints out last line
                          $data= substr($buffer, 0, $Leof);
                          print {$LOG} $data,"\n";
                        #  print {$LOG} "total portbuffer chars = ", $sumpb,"\n";
                        #  print {$LOG} "-----eof----------\n";
                           $pass=$ob->write("thank you"); # works OK
                          last INPUT;
                           }
                   else {## no LF or EOF found
                        next;## skip the printing to the file
                         ## use this for diagnostics
                         print {$LOG} "-----NO LF, NO EOF ------\n";
                          print {$LOG} "buffer = ", $buffer,"\n";
                         print {$LOG} "portbuffer = ", $portbuffer,"\n";
                         print {$LOG} "Lcr = ",$Lcr, "\n";
                         print {$LOG} "Leof = ",$Leof, "\n";
                         print {$LOG} "---------------\n";
                        };
               }; ## end of while2
          }; ## end of while1
##-----------
close ($LOG);
## now close the serial port
# $ob->close ||croak "failed to close";
undef $ob;  ## frees memory back to Perl (but no error message)
#------------end ----------------
```

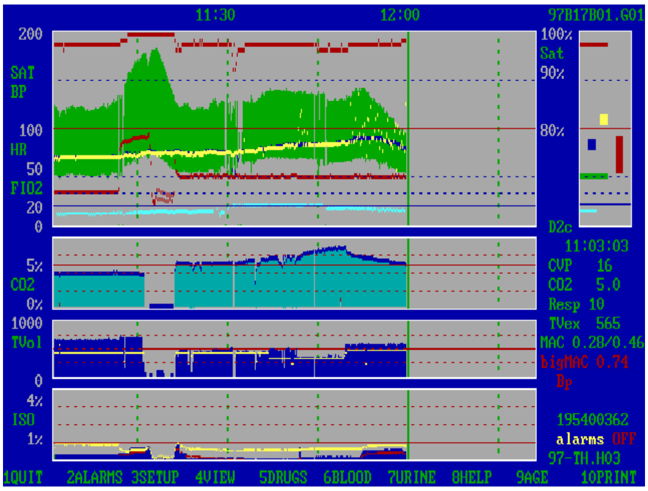
Chapter 6

Age corrected MAC

RWD Nickalls 2008 April 19, 2009 /aHOUSE/book-xenon/ch-macage01.tex

6.1 Introduction

The first implementation of the real-time age-corrected MAC output on the anaesthesia workstation was towards the end of 1996, soon after reading Mappleson's MAC paper (Mapleson 1996). The workstation program at that time was an MS-DOS application (written in QuickBasic 4.5) running in the thoracic theatre at the City Hospital.



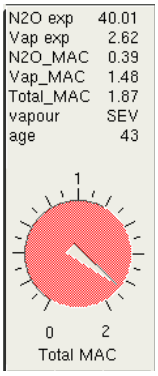
D2c
11:03:03
CVP 16
CO2 5.0
Resp 10
TVex 565
MAC 0.28/0.46
bigMAC 0.74
Bp
195400362
alarms OFF
97-TH.H03

Figure 6.1: Screenshot (November 1997) of the MS-DOS anaesthesia workstation program (version D2c), showing the age-corrected MAC ("bigMAC") value in a red-alert state (only 0·74) on the lower RHS of the screen. Other 'red-alert' states also indicated are for Bp (blood pressure—too low), and alarm sound OFF.

In practice this application was greatly facilitated by the excellent serial-port data stream output by the Datex Cardiocap and Capnomac Ultima series of anaesthesia monitors we then used (detailed in: Nickalls and Ramasubramanian 1995), since the data included agent name and inspired and expired vapour concentrations. Consequently, a practical real-time age-corrected MAC output display was straightforward and simple to implement, since all that was necessary was to write a small subroutine to calculate the value and display the numeric value continuously, and arrange for the value to be displayed in red and also trigger an audible alarm) when less than a critical value (initially I chose the value 0·86—see the program below).

A significant problem regarding the administration of anaesthesia at that time was the fact that no less than four inhalational anaesthetic vapours were in common use (halothane, isoflurane, desflurane, sevoflurane), it was essentially impossible for *anyone* to remember the appropriate settings for each combination of agent and age. Consequently the prospect of inadvertent awareness was ever present, and anaesthetists generally tended to learn how to use one or two agents for most things even though particular agents may well be more suitable in certain circumstances (eg desflurane with obesity etc).

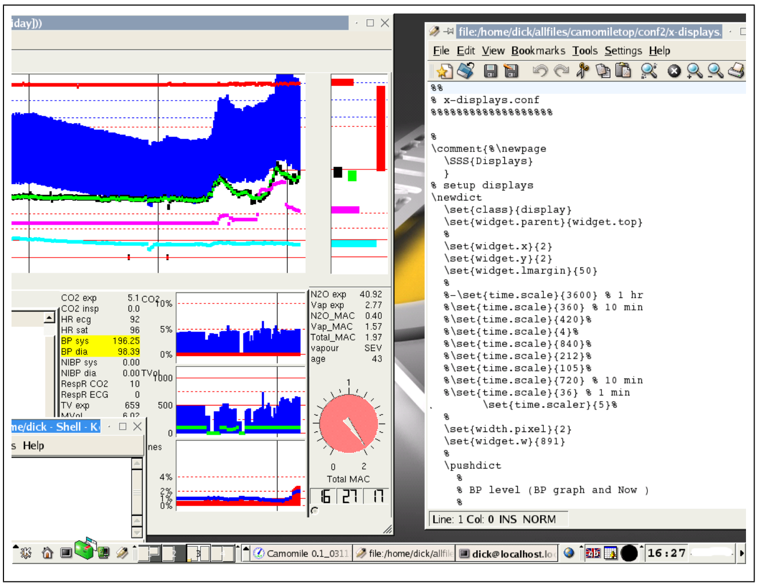
In view of this problem, the display of age-corrected MAC was particularly since one could now use any agent for any patient irrespective of age, quite safely simply by administering the agent in terms of MAC, and with the great benefit of essentially eliminating the possibility of inadvertent awareness simply by ensuring the age-corrected MAC was greater than a certain critical value—now taken to be 1 MAC (Hardman JG and Aitkenhead AR 2005). In fact we now had a working practical way of giving anaesthetics in terms of MAC units, as originally foreseen by Mapleson many years earlier in his insightful Clover lecture (Mapleson 1979). Our system of displaying real-time age-corrected MAC was at that time almost certainly the only such system in the UK, and possibly in the world.



```
N2O exp     40.01
Vap exp      2.62
N2O_MAC      0.39
Vap_MAC      1.48
Total_MAC    1.87
vapour        SEV
age            43
```

Figure 6.2:
Example of the new real-time age-corrected MAC-widget displayed by the anaesthesia workstation Linux software (© Nickalls RWD and Dales S (1996–2009)) interfaced to the Datex S/5 monitor. If the corrected MAC is too low or too high (as shown in this case—total MAC 1·87) then, in addition to sounding an audible alarm, the dial of the MAC-widget turns red.

The theatre program was later rewritten for the Linux operating system using the new Datex-Ohmeda AS3 monitors, having a much better data-stream (detailed in the Datex chapter). This allowed a nice widget design and hence a much better age-corrected MAC screen display as shown in Figures 6.2, 6.3. This display was intuitive, easy to read and well liked.



```
CO2 exp       5.1
CO2 insp      0.0
HR ecg         92
HR sat         96
BP sys     196.25
BP dia      98.39
NIBP sys     0.00
NIBP dia     0.00
RespR CO2      10
RespR ECG       0
TV exp        659
MVol         6.02
```

```
N2O exp    40.92
Vap exp     2.77
N2O_MAC     0.40
Vap_MAC     1.57
Total_MAC   1.97
vapour       SEV
age           43
```

```
%%
% x-displays.conf
%%%%%%%%%%%%%%%%%%%%


%
\comment{%\newpage
  \SSS{Displays}
  }
% setup displays
\newdict
  \set{class}{display}
  \set{widget.parent}{widget.top}
  %
  \set{widget.x}{2}
  \set{widget.y}{2}
  \set{widget.lmargin}{50}
  %
  %-\set{time.scale}{3600} % 1 hr
  %\set{time.scale}{360} % 10 min
  %\set{time.scale}{420}%
  %\set{time.scale}{4}%
  %\set{time.scale}{840}%
  %\set{time.scale}{212}%
  %\set{time.scale}{105}%
  %\set{time.scale}{720} % 10 min
  %\set{time.scale}{36} % 1 min
.       \set{time.scaler}{5}%
  %
  \set{width.pixel}{2}
  \set{widget.w}{891}
  %
  \pushdict
    %
    % BP level (BP graph and Now )
    %
```

Figure 6.3: Screenshot showing the Linux MAC widget in a red-alert state. Note that the main display screen (pushed to the LHS) is designed so that all the important minute-to-minute data and alarm data is positioned on the RHS of the main display screen, and so allows the main display screen to be moved towards the left in order to view other data, files, or images as required. In this example a file is opened on the RHS of the PC screen.

6.1.1 MAC subroutine (MS-DOS)

The agent name and the end-tidal concentration (output by the Datex monitor) were used as inputs for the calculation, the MAC$_{age=40}$ values for each agent being stored in simple look-up table in the following subroutine (written in QuickBASIC 4.5).

```
REM MS–DOS program
REM 1996 QuickBASIC 4.5
SUB mac (n2opercent, vapourname$, etvapour, ageofpatient%, bmac)
REM ——————————
REM Determines the current value of MAC
REM using the recent paper by Mapleson (BJA, 1996, vol 76, p 179–185)
REM Effect of age on MAC in humans: a meta–analysis
REM ————————————
REM new MAC sub using etn2o
REM returns the value of BIGMAC (bmac)
REM this is the newMAC which works correctly
REM ———————
IF etvapour < 0 THEN etvapour = .001
n2o = n2opercent
v$ = vapourname$
vap = etvapour
A% = ageofpatient%
deltaage% = A% – 40
```

```
BB = -.00269
REM ———————————
REM this MAC sub is called from the end of PLOTVAPOUR sub
REM vapour is on Datex Ultima BOO and C04 (13,3) data strings
REM vapourcode$= ISO, HAL etc  = "    " when not selected
IF v$ = "" THEN mac40 = 0
IF v$ = "HAL" THEN mac40 = .75
IF v$ = "ISO" THEN mac40 = 1.17
IF v$ = "ENF" THEN mac40 = 1.63
IF v$ = "SEV" THEN mac40 = 1.8
IF v$ = "DES" THEN mac40 = 6.6
REM mac40 for N2O = 104
REM ——————————
REM do N2O calculation first
REM restrict n2o to zero or above
IF n2o < 0 THEN n2o = 0
REM eqn   mac=(mac40)*10^(-0.00269* deltaage%)
macn2o = 104 * 10 ^ (BB * deltaage%)
IF macn2o <= 0 THEN
    Fmacn2o = .01: REM changed from 0 to .01  check
    ELSE
    Fmacn2o = n2o / macn2o
END IF
REM ———————————————
REM do VAPOUR calc next
REM eqn   mac=(mac40)*10^(-0.00269* deltaage%)
macvapour = mac40 * 10 ^ (BB * deltaage%)
IF macvapour <= 0 THEN
    totalFmac = Fmacn2o
    ELSE
    Fmacvapour = (vap / macvapour)
    totalFmac = Fmacvapour + Fmacn2o
END IF
REM ——————————————————————————————————
REM do not print to screen if printing last 20 mins fast data
IF pl20mf$ = "on" THEN GOTO MAClastline
REM ——————————————————————————————————
A = Fmacn2o
B = Fmacvapour
c = totalFmac
REM ——————————————————————————————————
COLOR green, screenbackcolour
REM cannot print digits with PRINT USING and
REM strings in same PRINT statement, so therefore
REM we have to print them separately (red if vap mac=0)
LOCATE 18, 68: PRINT SPACE$(11)
LOCATE 18, 68: PRINT "MAC ";
    IF B <= 0 THEN
        COLOR red, screenbackcolour
        PRINT USING "#.##"; B;
        COLOR green, screenbackcolour
    ELSE
```

```
        PRINT USING "#.##"; B;
    END IF
    PRINT "/";
    PRINT USING "#.##"; A
REM --- print in red if bigmac less than .86
IF c < 0.86 THEN
          COLOR red, screenbackcolour
      ELSE
          COLOR green, screenbackcolour
END IF
LOCATE 19, 68: PRINT SPACE$(10)
LOCATE 19, 68: PRINT "bigMAC ";
   PRINT USING "#.##"; c
REM ----------------------------------
REM now return to normal screen colours
COLOR screenforecolour, screenbackcolour
MAClastline:
bmac = c
END SUB
$%
```

6.2 Age corrected MAC charts

Sometime during the next couple of years I started wondering how I could create a paper nomogram-type chart for determining age-corrected MAC for use when I did lists at the QMC, since (a) I was unable then to use my computer program (based in the thoracic theatre at the City Hospital), and (b) it was impossible to use the data presented in the Mapleson 1996 paper in a clinical setting to guide at all accurately the appropriate choice of end-tidal agent concentration for a particular patient.

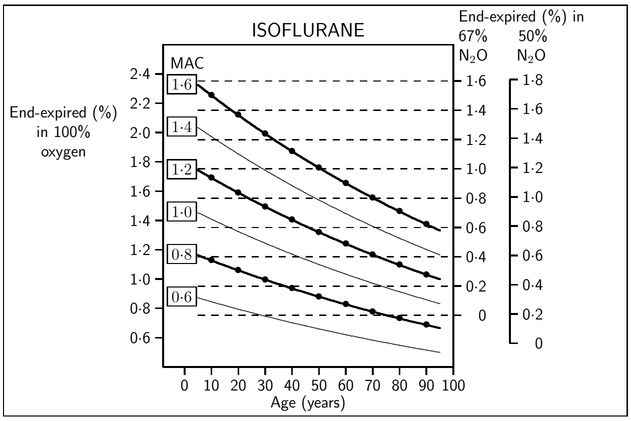


Figure 6.4: One of the first age-corrected iso-MAC charts, drawn using mathsPIC.

The main problem was figuring out how best to incorporate the optional and flexible use of nitrous oxide, since the charts would not be particularly useful clinically unless they easily allowed for the effect of nitrous oxide. The design of such a chart was not straightforward, and it was quite a long time before I formulated a suitable design which allowed nitrous-oxide use (see Figure 6.4). The solution lay in the generally held view that MAC-multiples were additive, and hence the nitrous oxide scale could simply be shifted by an agent-specific amount. Eventually a single chart for each inhalational agent was generated using Perl and mathsPIC (Nickalls 1999, 2000; Syropoulos and Nickalls 2000), and this was then tested clinically over a period of time.

Encouraged by colleagues who tested these charts (one for each of the three main inhalational agents), a paper was submitted to the *British Journal of Anaesthesia* in November 2001. A revised version was submitted in February 2003 and was published later that year (Nickalls and Mapleson 2003). The article was also the subject of an editorial (White, 2003). Since then the these age-corrected iso-MAC charts have been included in the *Oxford handbook of anaesthesia* (Allman and Wilson 2006).

6.3 Generating the charts

The charts were generated using QuickBasic 4.5 (MS-DOS), Perl and mathsPIC. I originally used a QuickBasic program (e.g. `iso-mac.dat`; see below) to generate the agent-specific data-files (for isoflurane, sevoflurane, desflurane) containing the data points for each of the iso-MAC curve (i.e. for the curves associated with the MAC values 0·6, 0·8, 1·0, 1·2, 1·4, 1·6). These data-files were coded with the letters j,k,m,n,p,q For example the following program `iso-mac.bas` generated the isoflurane data-file `isoqdata.dat` (i.e. the data-file for the 'q' (iso-MAC 1·6) curve for isoflurane). In order to generate all the different data-files (a total of 3 × 6 different data-files) the program was run many times, each run having different values enabled for agent and MAC etc.

```
REM new  iso-mac.bas
COLOR 15, 1
CLS
REM IF ageofpatient% < 1 THEN ageofpatient% = 1
REM ————————————
REM this MAC sub is called from the end of PLOTVAPOUR sub
REM vapour is on B00 and C04 (13,3) data strings
REM vapourcode$= ISO, HAL etc  = "    " when not selected
REM IF v$ = "    " THEN mac40 = 0
REM IF v$ = "HAL" THEN mac40 = .75
REM IF v$ = "ISO" THEN mac40 = 1.17
REM IF v$ = "ENF" THEN mac40 = 1.63
REM IF v$ = "SEV" THEN mac40 = 1.8
REM IF v$ = "DES" THEN mac40 = 6.6
REM mac40 for N2O = 104
REM ———————————
REM  etn2o = 100 - (eto2 + etco2 + etvap)
REM ————————————————————
REM do N2O calculation first
REM restrict n2o to zero or above
REM IF n2o < 0 THEN n2o = 0
REM eqn   mac=(mac40)*10^(-0.00269* deltaage%)
REM ----------------

REM q = 1.6 mac = 1.17
REM p = 1.4 mac = 1.17
REM n = 1.2 mac = 1.17
REM m = 1 mac = 1.17
REM k = 0.8 mac = 1.17
REM j = 0.6 mac = 1.17

OPEN "isoqdata.dat" FOR OUTPUT AS #1
n = 1.6
code$ = "q"

mac40 = 1.17: REM isoflurane

REM ----------------
PRINT #1, "%% " + code$ + "= mac40(iso) * "; n
FOR j = 5 TO 95 STEP 5
REM j = age
deltaage = j - 40
BB = -.00269
 mac = (n * mac40) * 10 ^ (BB * deltaage)
PRINT j, mac
PRINT #1, "point(" + code$; j; "){"; j; ","; mac; "}"
s$ = s$ + code$ + STR$(j) + SPACE$(1)
NEXT j

PRINT #1,
PRINT #1, "drawline(" + s$ + ")"
REM $-------------
```

6.3.1 A data file for a single iso-MAC curve

The following output data-file (`isoqdata.dat`) was generated by the above program. This data-file contained the mathsPIC code for drawing the iso-MAC 1·6 curve (‘q’) for the agent isoflurane. This file was then one of the input files for another mathsPIC program which drew the whole graph.

```
%% isoqdata.dat
%% q= mac40(iso) *  1.6
 point(q 5 ){ 5 , 2.325176} %% manual
 point(q 10 ){ 10 , 2.25427 }
 point(q 15 ){ 15 , 2.185525 }
 point(q 20 ){ 20 , 2.118877 }
 point(q 25 ){ 25 , 2.054262 }
 point(q 30 ){ 30 , 1.991617 }
 point(q 35 ){ 35 , 1.930882 }
 point(q 40 ){ 40 , 1.872 }
 point(q 45 ){ 45 , 1.814913 }
 point(q 50 ){ 50 , 1.759567 }
 point(q 55 ){ 55 , 1.705909 }
 point(q 60 ){ 60 , 1.653887 }
 point(q 65 ){ 65 , 1.603451 }
 point(q 70 ){ 70 , 1.554554 }
 point(q 75 ){ 75 , 1.507148 }
 point(q 80 ){ 80 , 1.461187 }
 point(q 85 ){ 85 , 1.416628 }
 point(q 90 ){ 90 , 1.373428 }
 point(q 95 ){ 95 , 1.331545 }

 drawline(q 5 q 10 q 15 q 20 q 25 q 30 q 35 q 40 q 45 q 50
     q 55 q 60 q 65 q 70 q 75 q 80 q 85 q 90 q 95 )
 drawpoint(q 10  q 20  q 30  q 40  q 50  q 60  q 70  q 80
     q 90 )
```

6.3.2 mathsPIC script for drawing the whole graph

Once having generated all the different data-files (above), a mathsPIC script was written to draw the axes, and to draw the graph by inputting all the relevant data-files. For example, the following mathsPIC script (`mac-iso7.m`) inputs each of the various data-files (one for each iso-MAC curve) and draws the complete isoflurane graph, outputting the LaTeX form of the graph.

For those not familiar with TeX and LaTeX the complete process to be run through is roughly as follows: we first process the mathsPIC script via the mathsPIC program (a Perl program) to generate the TeX (`.mt`) output file, and then we LaTeX this file to generate the (`.dvi`) output file. Next we generate a PostScript version (using the `dvips` utility, and then define the Bounding Box (BB) (using GhostScript) and form the EPS version (i.e. by including the BB coordinates and then renaming the file). Finally we generate the associated (`.pdf`) files using the `epstopdf` utility.

Note that the particular mathsPIC program used at that time was actually an early β version of the final mathsPIC program (Syropoulos A and Nickalls RWD 2005), so that the following mathsPIC script contains instances of the old `\variable(){}` commands which were still being used (eventually changed to the Perl-like format `\var(){}`).

```
%% mac-iso7.m (modified from mac-iso5.m)
%% Feb 1st 2003
%% final graph/chart for the bja
%% wih decimals ($\cdot$) and \fbox{}
%% new curves for anaesthesia
% mathsPIC

\documentclass[a4paper,12pt]{article}
\usepackage{pictexwd}
\begin{document}
\thispagestyle{empty}%% to avoid page nos
\oddsidemargin=-17mm
%\framebox{%
\beginpicture
%-----------------

%% use sf font for figures for BJA
\fontfamily{cmss}\selectfont\normalsize
\linethickness=0.9pt %% = normalsize  (my manual p 23)
```

```

      %% structure copied from mac-des.m
%%----------
%% ISOflurane Delta for N2O = 0.75 = (66.6666/104)*1.17
pointnumber(200)
%% y units = 12cm/2.2 = 5.454545
%paper{units(mm,5.454545cm) xrange(-5,100)
    yrange(0.4,2.6) axes(L) ticks(10,0.2)}
paper{units(0.7mm,3.818181cm) xrange(-8,100)
    yrange(0.4,2.6) axes(T)}

%-------------------
%% want to print only some of the L axis scale (0.6-2.4),
    so do it manually
\axis left
\      ticks withvalues      0{$\cdot$}6   0{$\cdot$}8
    1{$\cdot$}0   1{$\cdot$}2   1{$\cdot$}4   1{$\cdot$}6
\              1{$\cdot$}8  2{$\cdot$}0   2{$\cdot$}2
    2{$\cdot$}4  /
\             at    0.60   0.80   1.00   1.20   1.40
\             1.60   1.80   2.00  2.20   2.40    / /
%----------------------------
\axis bottom
\  ticks withvalues  0  10  20  30  40  50  60  70  80  90
     100 /
\  at                0  10  20  30  40  50  60  70  80  90
     100 / /
%----------------------------
\axis right
%%%     {using N2O  67%}} shift = 0.7523
\      ticks withvalues    0    0{$\cdot$}2    0{$\cdot$}4
    0{$\cdot$}6
\                         0{$\cdot$}8  1{$\cdot$}0
    1{$\cdot$}2    1{$\cdot$}4
\                         1{$\cdot$}6  /
\            at 0.7523   0.9523   1.1523   1.3523   1.5523
    1.7523   1.9523  2.1523
\               2.3523 / /

%-------------------------------------
%% extra 50% right axis  shift = 0.5614
%% since this axis is off the graph then need new paper
    command
%% but do not use axis() option
paper{units(0.7mm,3.818181cm) xrange(-8,121)
    yrange(0.5614,2.3614) }
\axis right   %% seconds right axis for 50% oxygen  shift
    = 0.5614
\      ticks withvalues    0      0{$\cdot$}2      0{$\cdot$}4
          0{$\cdot$}6      0{$\cdot$}8
\      1{$\cdot$}0     1{$\cdot$}2     1{$\cdot$}4
    1{$\cdot$}6  1{$\cdot$}8 /
\                      at 0.5614   0.7614   0.9614    1.1614
    1.3614
```

```
\       1.5614  1.7614  1.9614   2.1614  2.3614 //
%------------------------------------------------

%%beginSKIP
\newcommand{\thickline}{\setplotsymbol({\Large .})}%
\newcommand{\thinline}{\setplotsymbol({\tiny .})}%

\thickline%
inputfile(isoqdata.dat)   %1.6
\thinline%
inputfile(isopdata.dat)   %1.4
\thickline%
inputfile(isondata.dat)   % 1.2
\thinline%
inputfile(isomdata.dat)   % 1
\thickline%
inputfile(isokdata.dat)   % 0.8
\thinline%
inputfile(isojdata.dat)   %0.6
%%endSKIP
%------------------------------------------------
%%from mac-des.m
variable(x){-1}
variable(x2){x, advance(2)}
point(h){x2,2.475}
text(MAC){h}
%% vertical diff = 0.29 units %% 0.28
variable(d){0.29}

variable(h6){0.88}   %0.9
text(\fbox{$0{\cdot}6$}){x,h6}

variable(h8){h6, advance(d)}
text(\fbox{$0{\cdot}8$}){x,h8}

variable(h10){h8, advance(d)}
text(\fbox{$1{\cdot}0$}){x,h10}

variable(h12){h10, advance(d)}
text(\fbox{$1{\cdot}2$}){x,h12}

variable(h14){h12, advance(d)}
text(\fbox{$1{\cdot}4$}){x,h14}

variable(h16){h14, advance(d)}
text(\fbox{$1{\cdot}6$}){x,h16}

%---------------------------
\newcommand{\myleft}{%
%\framebox{
\begin{minipage}{29mm}\centering%
\ End-expired (\%)\\%
\ in 100\% \\%
\ oxygen\\
\end{minipage}%
%\ }%
\ }%

text(\myleft){-45, 2.0}

%-----------------------------------------
\newcommand{\myrightb}{%
    %\fbox{%
\    \begin{minipage}{4cm}%
\    End-expired (\%) in\\
\    67\%\hspace{8mm}50\%\\
\    N$_2$O\hspace{7.5mm}N$_2$O
\    \end{minipage}
%  }%
\    }% end of newcommand
text(\myrightb){102, 2.657}[l]  %% was 2.6
%------------------------------------------

\newcommand{\mybottom}{Age (years)}%
text(\mybottom){46, 0.15}

%%text(\copyright\ RWD Nickalls\ 2001){22,0.5}

text(\large ISOFLURANE){46, 2.7}  %% 80

%---------------------------------------------
% draw horizontal dashed lines
%%\linethickness=0.4pt %% equivalent to {\tiny .}
\linethickness=0.6pt %% half way between tiny and normalsize
\setdashes
variable(x5){5}       %% Left X value
variable(x6){100}     %% Right X value
variable(y16){2.3523}
variable(y14){2.1523}
variable(y12){1.9523}
variable(y10){1.7523}
variable(y08){1.5523}
variable(y06){1.3523}
variable(y04){1.1523}
variable(y02){0.9523}    %% = 0.7523 + 0.2
variable(y00){0.7523}    %% = 0.7523

point(L16){x5, y16}
point(R16){x6, y16}

point(L14){x5, y14}
point(R14){x6, y14}

point(L12){x5, y12}
point(R12){x6, y12}

point(L10){x5, y10}
point(R10){x6, y10}

point(L08){x5, y08}
point(R08){x6, y08}

point(L06){x5, y06}
point(R06){x6, y06}

point(L04){x5, y04}
point(R04){x6, y04}

point(L02){x5, y02}
point(R02){x6, y02}

point(L00){x5, y00}
point(R00){x6, y00}

%% draw the dashes from Left to Right
%% (so have small gap at right axis)
drawline(L16R16, L14R14, L12R12, L10R10,L08R08, L06R06,
    L04R04, L02R02, L00R00)

\endpicture
%\ } %framebox
\end{document}
```

The following example is the TEX code output by the above mathsPIC program.

```
%* -----------------------------------------------
%* mathsPIC 2.1g1
%* Copyright (c) RWD Nickalls 1999-2002
%* Email: dicknickalls@compuserve.com
%* Date (m/d/y) : 02-02-2003  16:22:19
%* Command Line: /b/s  MAC-ISO7.M
%* Input Filename:  MAC-ISO7.M
%* Output Filename: MAC-ISO7.MT
%* -----------------------------------------------
%% mac-iso7.m (modified from mac-iso5.m)
%% Feb 1st 2003
%% final graph/chart for the bja
%% wih decimals ($\cdot$) and \fbox{}
%% new curves for anaesthesia
% mathsPIC
\documentclass[a4paper,12pt]{article}
\usepackage{pictexwd}
\begin{document}
\thispagestyle{empty}%% to avoid page nos
\oddsidemargin=-17mm
\framebox{%
\beginpicture
%----------------
%% use sf font for figures for BJA
\fontfamily{cmss}\selectfont\normalsize
\linethickness=0.9pt %% = normalsize  (my manual p 23)
```

```
    %% structure copied from mac-des.m
%%----------
%% ISOflurane Delta for N2O = 0.75 = (66.6666/104)*1.17
%% pointnumber(200)
%% y units = 12cm/2.2 = 5.454545
%paper{units(mm,5.454545cm) xrange(-5,100) yrange(0.4,2.6) axes(L) ticks(10,0.2)}
%% paper{units(0.7mm,3.818181cm)xrange(-8,100)yrange(0.4,2.6)axes(T)}
\setcoordinatesystem units < .7mm, 3.818181cm>
%% ... note: xunits & yunits are different
\setplotarea x from -8 to  100, y from  .4 to  2.6
\axis top /
%-------------------
%% want to print only some of the L axis scale (0.6-2.4), so do it manually
\axis left
      ticks withvalues     0{$\cdot$}6   0{$\cdot$}8   1{$\cdot$}0   1{$\cdot$}2   1{$\cdot$}4   1{$\cdot$}6
              1{$\cdot$}8  2{$\cdot$}0   2{$\cdot$}2   2{$\cdot$}4  /
              at   0.60  0.80  1.00  1.20  1.40
              1.60  1.80  2.00 2.20  2.40   / /
%-----------------------------
\axis bottom
   ticks withvalues  0  10  20  30  40  50  60  70  80  90  100 /
   at                0  10  20  30  40  50  60  70  80  90  100 / /
%-----------------------------
\axis right
%%%    {using N2O  67%}} shift = 0.7523
      ticks withvalues   0   0{$\cdot$}2   0{$\cdot$}4   0{$\cdot$}6
                        0{$\cdot$}8  1{$\cdot$}0   1{$\cdot$}2   1{$\cdot$}4
                       1{$\cdot$}6  /
             at 0.7523  0.9523  1.1523  1.3523  1.5523  1.7523  1.9523  2.1523
                2.3523 / /
%---------------------------------------
%% extra 50% right axis  shift = 0.5614
%% since this axis is off the graph then need new paper command
%% but do not use axis() option
%% paper{units(0.7mm,3.818181cm)xrange(-8,121)yrange(0.5614,2.3614)}
\setcoordinatesystem units < .7mm, 3.818181cm>
%% ... note: xunits & yunits are different
\setplotarea x from -8 to  121, y from  .5614 to  2.3614
\axis right  %% seconds right axis for 50% oxygen  shift = 0.5614
      ticks withvalues   0     0{$\cdot$}2     0{$\cdot$}4
```

```
                  0{$\cdot$}6     0{$\cdot$}8
        1{$\cdot$}0     1{$\cdot$}2     1{$\cdot$}4
            1{$\cdot$}6   1{$\cdot$}8 /
                       at 0.5614   0.7614   0.9614    1.1614
                           1.3614
        1.5614 1.7614 1.9614  2.1614 2.3614 / /
%------------------------------------------
%%beginSKIP
\newcommand{\thickline}{\setplotsymbol({\Large .})}%
\newcommand{\thinline}{\setplotsymbol({\tiny .})}%
\thickline%
%% inputfile(isoqdata.dat)  %1.6
%% ... start of file <isoqdata.dat>
%% q= mac40(iso) *  1.6
%% point(q5){5,2.325176}   ( 5  , 2.325176 )  %% manual
%% point(q10){10,2.25427}   ( 10  , 2.25427  )
%% point(q15){15,2.185525}   ( 15  , 2.185525  )
%% point(q20){20,2.118877}   ( 20  , 2.118877  )
%% point(q25){25,2.054262}   ( 25  , 2.054262  )
%% point(q30){30,1.991617}   ( 30  , 1.991617  )
%% point(q35){35,1.930882}   ( 35  , 1.930882  )
%% point(q40){40,1.872}   ( 40  , 1.872  )
%% point(q45){45,1.814913}   ( 45  , 1.814913  )
%% point(q50){50,1.759567}   ( 50  , 1.759567  )
%% point(q55){55,1.705909}   ( 55  , 1.705909  )
%% point(q60){60,1.653887}   ( 60  , 1.653887  )
%% point(q65){65,1.603451}   ( 65  , 1.603451  )
%% point(q70){70,1.554554}   ( 70  , 1.554554  )
%% point(q75){75,1.507148}   ( 75  , 1.507148  )
%% point(q80){80,1.461187}   ( 80  , 1.461187  )
%% point(q85){85,1.416628}   ( 85  , 1.416628  )
%% point(q90){90,1.373428}   ( 90  , 1.373428  )
%% point(q95){95,1.331545}   ( 95  , 1.331545  )
%%
    drawline(q5q10q15q20q25q30q35q40q45q50q55q60q65q70q75q80q85q90q95)
\plot   5  2.325176      10  2.25427 /  %% q5q10
\plot   10  2.25427      15  2.185525 /  %% q10q15
\plot   15  2.185525      20  2.118877 /  %% q15q20
\plot   20  2.118877      25  2.054262 /  %% q20q25
\plot   25  2.054262      30  1.991617 /  %% q25q30
\plot   30  1.991617      35  1.930882 /  %% q30q35
\plot   35  1.930882      40  1.872 /  %% q35q40
\plot   40  1.872      45  1.814913 /  %% q40q45
\plot   45  1.814913      50  1.759567 /  %% q45q50
\plot   50  1.759567      55  1.705909 /  %% q50q55
\plot   55  1.705909      60  1.653887 /  %% q55q60
\plot   60  1.653887      65  1.603451 /  %% q60q65
\plot   65  1.603451      70  1.554554 /  %% q65q70
\plot   70  1.554554      75  1.507148 /  %% q70q75
\plot   75  1.507148      80  1.461187 /  %% q75q80
\plot   80  1.461187      85  1.416628 /  %% q80q85
\plot   85  1.416628      90  1.373428 /  %% q85q90
\plot   90  1.373428      95  1.331545 /  %% q90q95
%% drawpoint(q10q20q30q40q50q60q70q80q90)
```

```
\put {$\bullet$} at  10  2.25427  %% q10
\put {$\bullet$} at  20  2.118877  %% q20
\put {$\bullet$} at  30  1.991617  %% q30
\put {$\bullet$} at  40  1.872  %% q40
\put {$\bullet$} at  50  1.759567  %% q50
\put {$\bullet$} at  60  1.653887  %% q60
\put {$\bullet$} at  70  1.554554  %% q70
\put {$\bullet$} at  80  1.461187  %% q80
\put {$\bullet$} at  90  1.373428  %% q90
%% ... end of file  <isoqdata.dat>
\thinline%
%% inputfile(isopdata.dat)  %1.4
%% ... start of file <isopdata.dat>
%% p= mac40(iso) *  1.4
%% point(p5){5,2.034529}  ( 5 , 2.034529 )  %% manual
%% point(p10){10,1.972486}  ( 10 , 1.972486 )
%% point(p15){15,1.912335}  ( 15 , 1.912335 )
%% point(p20){20,1.854018}  ( 20 , 1.854018 )
%% point(p25){25,1.797479}  ( 25 , 1.797479 )
%% point(p30){30,1.742665}  ( 30 , 1.742665 )
%% point(p35){35,1.689522}  ( 35 , 1.689522 )
%% point(p40){40,1.638}  ( 40 , 1.638 )
%% point(p45){45,1.588049}  ( 45 , 1.588049 )
%% point(p50){50,1.539621}  ( 50 , 1.539621 )
%% point(p55){55,1.49267}  ( 55 , 1.49267 )
%% point(p60){60,1.447151}  ( 60 , 1.447151 )
%% point(p65){65,1.40302}  ( 65 , 1.40302 )
%% point(p70){70,1.360235}  ( 70 , 1.360235 )
%% point(p75){75,1.318754}  ( 75 , 1.318754 )
%% point(p80){80,1.278539}  ( 80 , 1.278539 )
%% point(p85){85,1.23955}  ( 85 , 1.23955 )
%% point(p90){90,1.201749}  ( 90 , 1.201749 )
%% point(p95){95,1.165102}  ( 95 , 1.165102 )
%% drawline(p5p10p15p20p25p30p35p40p45p50p55p60p65p70p75p80p85p90p95)
\plot   5  2.034529    10  1.972486 /  %% p5p10
\plot   10  1.972486    15  1.912335 /  %% p10p15
\plot   15  1.912335    20  1.854018 /  %% p15p20
\plot   20  1.854018    25  1.797479 /  %% p20p25
\plot   25  1.797479    30  1.742665 /  %% p25p30
\plot   30  1.742665    35  1.689522 /  %% p30p35
\plot   35  1.689522    40  1.638 /  %% p35p40
\plot   40  1.638    45  1.588049 /  %% p40p45
\plot   45  1.588049    50  1.539621 /  %% p45p50
\plot   50  1.539621    55  1.49267 /  %% p50p55
\plot   55  1.49267    60  1.447151 /  %% p55p60
\plot   60  1.447151    65  1.40302 /  %% p60p65
\plot   65  1.40302    70  1.360235 /  %% p65p70
\plot   70  1.360235    75  1.318754 /  %% p70p75
\plot   75  1.318754    80  1.278539 /  %% p75p80
\plot   80  1.278539    85  1.23955 /  %% p80p85
\plot   85  1.23955    90  1.201749 /  %% p85p90
\plot   90  1.201749    95  1.165102 /  %% p90p95
%% ... end of file  <isopdata.dat>
```

```
\thickline%
%% inputfile(isondata.dat)  % 1.2
%% ... start of file <isondata.dat>
%% n= mac40(iso) *  1.2
%% point(n5){5,1.743882}  ( 5 , 1.743882 )  %% manual
%% point(n10){10,1.690702}  ( 10 , 1.690702 )
%% point(n15){15,1.639144}  ( 15 , 1.639144 )
%% point(n20){20,1.589158}  ( 20 , 1.589158 )
%% point(n25){25,1.540697}  ( 25 , 1.540697 )
%% point(n30){30,1.493713}  ( 30 , 1.493713 )
%% point(n35){35,1.448162}  ( 35 , 1.448162 )
%% point(n40){40,1.404}  ( 40 , 1.404 )
%% point(n45){45,1.361185}  ( 45 , 1.361185 )
%% point(n50){50,1.319675}  ( 50 , 1.319675 )
%% point(n55){55,1.279432}  ( 55 , 1.279432 )
%% point(n60){60,1.240415}  ( 60 , 1.240415 )
%% point(n65){65,1.202589}  ( 65 , 1.202589 )
%% point(n70){70,1.165916}  ( 70 , 1.165916 )
%% point(n75){75,1.130361}  ( 75 , 1.130361 )
%% point(n80){80,1.09589}  ( 80 , 1.09589 )
%% point(n85){85,1.062471}  ( 85 , 1.062471 )
%% point(n90){90,1.030071}  ( 90 , 1.030071 )
%% point(n95){95,.9986587}  ( 95 , .9986587 )
%% drawline(n5n10n15n20n25n30n35n40n45n50n55n60n65n70n75n80n85n90n95)
\plot  5  1.743882    10  1.690702 /  %% n5n10
\plot  10  1.690702    15  1.639144 /  %% n10n15
\plot  15  1.639144    20  1.589158 /  %% n15n20
\plot  20  1.589158    25  1.540697 /  %% n20n25
\plot  25  1.540697    30  1.493713 /  %% n25n30
\plot  30  1.493713    35  1.448162 /  %% n30n35
\plot  35  1.448162    40  1.404 /  %% n35n40
\plot  40  1.404    45  1.361185 /  %% n40n45
\plot  45  1.361185    50  1.319675 /  %% n45n50
\plot  50  1.319675    55  1.279432 /  %% n50n55
\plot  55  1.279432    60  1.240415 /  %% n55n60
\plot  60  1.240415    65  1.202589 /  %% n60n65
\plot  65  1.202589    70  1.165916 /  %% n65n70
\plot  70  1.165916    75  1.130361 /  %% n70n75
\plot  75  1.130361    80  1.09589 /  %% n75n80
\plot  80  1.09589    85  1.062471 /  %% n80n85
\plot  85  1.062471    90  1.030071 /  %% n85n90
\plot  90  1.030071    95  .9986587 /  %% n90n95
%% drawpoint(n10n20n30n40n50n60n70n80n90)
\put {$\bullet$} at  10  1.690702  %% n10
\put {$\bullet$} at  20  1.589158  %% n20
\put {$\bullet$} at  30  1.493713  %% n30
\put {$\bullet$} at  40  1.404  %% n40
\put {$\bullet$} at  50  1.319675  %% n50
\put {$\bullet$} at  60  1.240415  %% n60
\put {$\bullet$} at  70  1.165916  %% n70
\put {$\bullet$} at  80  1.09589  %% n80
\put {$\bullet$} at  90  1.030071  %% n90
%% ... end of file  <isondata.dat>
```

```
\thinline%
%% inputfile(isomdata.dat)  % 1
%% ...  start  of  file <isomdata.dat>
%% m= mac40(iso) *  1
%% point(m5){5,1.453235}  ( 5  , 1.453235  )
%% point(m10){10,1.408918}  ( 10  , 1.408918  )
%% point(m15){15,1.365953}  ( 15  , 1.365953  )
%% point(m20){20,1.324298}  ( 20  , 1.324298  )
%% point(m25){25,1.283914}  ( 25  , 1.283914  )
%% point(m30){30,1.244761}  ( 30  , 1.244761  )
%% point(m35){35,1.206802}  ( 35  , 1.206802  )
%% point(m40){40,1.17}  ( 40  , 1.17  )
%% point(m45){45,1.134321}  ( 45  , 1.134321  )
%% point(m50){50,1.099729}  ( 50  , 1.099729  )
%% point(m55){55,1.066193}  ( 55  , 1.066193  )
%% point(m60){60,1.033679}  ( 60  , 1.033679  )
%% point(m65){65,1.002157}  ( 65  , 1.002157  )
%% point(m70){70,.9715963}  ( 70  , .9715963  )
%% point(m75){75,.9419674}  ( 75  , .9419674  )
%% point(m80){80,.9132419}  ( 80  , .9132419  )
%% point(m85){85,.8853925}  ( 85  , .8853925  )
%% point(m90){90,.8583924}  ( 90  , .8583924  )
%% point(m95){95,.8322156}  ( 95  , .8322156  )
%% drawline(m5m10m15m20m25m30m35m40m45m50m55m60m65m70m75m80m85m90m95)
\plot   5   1.453235      10   1.408918  /   %% m5m10
\plot   10   1.408918      15   1.365953  /   %% m10m15
\plot   15   1.365953      20   1.324298  /   %% m15m20
\plot   20   1.324298      25   1.283914  /   %% m20m25
\plot   25   1.283914      30   1.244761  /   %% m25m30
\plot   30   1.244761      35   1.206802  /   %% m30m35
\plot   35   1.206802      40   1.17  /  %% m35m40
\plot   40   1.17     45   1.134321  /  %% m40m45
\plot   45   1.134321      50   1.099729  /   %% m45m50
\plot   50   1.099729      55   1.066193  /   %% m50m55
\plot   55   1.066193      60   1.033679  /   %% m55m60
\plot   60   1.033679      65   1.002157  /   %% m60m65
\plot   65   1.002157      70   .9715963  /   %% m65m70
\plot   70   .9715963      75   .9419674  /   %% m70m75
\plot   75   .9419674      80   .9132419  /   %% m75m80
\plot   80   .9132419      85   .8853925  /   %% m80m85
\plot   85   .8853925      90   .8583924  /   %% m85m90
\plot   90   .8583924      95   .8322156  /   %% m90m95
%% ... end  of  file   <isomdata.dat>
\thickline%
%% inputfile(isokdata.dat)  % 0.8
%% ...  start  of  file <isokdata.dat>
%% k= mac40(iso) *  .8
%% point(k5){5,1.162588}  ( 5  , 1.162588  )  %% manual
%% point(k10){10,1.127135}  ( 10  , 1.127135  )
%% point(k15){15,1.092763}  ( 15  , 1.092763  )
%% point(k20){20,1.059439}  ( 20  , 1.059439  )
%% point(k25){25,1.027131}  ( 25  , 1.027131  )
%% point(k30){30,.9958085}  ( 30  , .9958085  )
%% point(k35){35,.9654412}  ( 35 , .9654412 )
%% point(k40){40,.936}  ( 40 , .936 )
%% point(k45){45,.9074566}  ( 45 , .9074566 )
%% point(k50){50,.8797836}  ( 50 , .8797836 )
%% point(k55){55,.8529544}  ( 55 , .8529544 )
%% point(k60){60,.8269435}  ( 60 , .8269435 )
%% point(k65){65,.8017257}  ( 65 , .8017257 )
%% point(k70){70,.7772771}  ( 70 , .7772771 )
%% point(k75){75,.7535739}  ( 75 , .7535739 )
%% point(k80){80,.7305936}  ( 80 , .7305936 )
%% point(k85){85,.708314}  ( 85 , .708314 )
%% point(k90){90,.6867139}  ( 90 , .6867139 )
%% point(k95){95,.6657725}  ( 95 , .6657725 )
%% drawline(k5k10k15k20k25k30k35k40k45k50k55k60k65k70k75k80k85k90k95)
\plot   5   1.162588    10   1.127135 /  %% k5k10
\plot   10   1.127135    15   1.092763 /  %% k10k15
\plot   15   1.092763    20   1.059439 /  %% k15k20
\plot   20   1.059439    25   1.027131 /  %% k20k25
\plot   25   1.027131    30   .9958085 /  %% k25k30
\plot   30   .9958085    35   .9654412 /  %% k30k35
\plot   35   .9654412    40   .936 /  %% k35k40
\plot   40   .936    45   .9074566 /  %% k40k45
\plot   45   .9074566    50   .8797836 /  %% k45k50
\plot   50   .8797836    55   .8529544 /  %% k50k55
\plot   55   .8529544    60   .8269435 /  %% k55k60
\plot   60   .8269435    65   .8017257 /  %% k60k65
\plot   65   .8017257    70   .7772771 /  %% k65k70
\plot   70   .7772771    75   .7535739 /  %% k70k75
\plot   75   .7535739    80   .7305936 /  %% k75k80
\plot   80   .7305936    85   .708314 /  %% k80k85
\plot   85   .708314    90   .6867139 /  %% k85k90
\plot   90   .6867139    95   .6657725 /  %% k90k95
%% drawpoint(k10k20k30k40k50k60k70k80k90)
\put {$\bullet$} at  10  1.127135  %% k10
\put {$\bullet$} at  20  1.059439  %% k20
\put {$\bullet$} at  30  .9958085  %% k30
\put {$\bullet$} at  40  .936  %% k40
\put {$\bullet$} at  50  .8797836  %% k50
\put {$\bullet$} at  60  .8269435  %% k60
\put {$\bullet$} at  70  .7772771  %% k70
\put {$\bullet$} at  80  .7305936  %% k80
\put {$\bullet$} at  90  .6867139  %% k90
%% ... end of file  <isokdata.dat>
\thinline%
%% inputfile(isojdata.dat)  %0.6
%% ...  start of file <isojdata.dat>
%% j= mac40(iso) *  .6
%% point(j5){5,.871941}  ( 5 , .871941 )  %% manual
%% point(j10){10,.8453511}  ( 10 , .8453511 )
%% point(j15){15,.819572}  ( 15 , .819572 )
%% point(j20){20,.794579}  ( 20 , .794579 )
%% point(j25){25,.7703483}  ( 25 , .7703483 )
%% point(j30){30,.7468564}  ( 30 , .7468564 )
%% point(j35){35,.7240809}  ( 35 , .7240809 )
%% point(j40){40,.702}  ( 40 , .702 )
%% point(j45){45,.6805924}  ( 45 , .6805924 )
%% point(j50){50,.6598377}  ( 50 , .6598377 )
%% point(j55){55,.6397159}  ( 55 , .6397159 )
%% point(j60){60,.6202077}  ( 60 , .6202077 )
%% point(j65){65,.6012943}  ( 65 , .6012943 )
%% point(j70){70,.5829578}  ( 70 , .5829578 )
%% point(j75){75,.5651804}  ( 75 , .5651804 )
%% point(j80){80,.5479452}  ( 80 , .5479452 )
%% point(j85){85,.5312355}  ( 85 , .5312355 )
%% point(j90){90,.5150355}  ( 90 , .5150355 )
%% point(j95){95,.4993294}  ( 95 , .4993294 )
%% drawline(j5j10j15j20j25j30j35j40j45j50j55j60j65j70j75j80j85j90j95)
\plot   5  .871941     10  .8453511 /  %% j5j10
\plot   10  .8453511     15  .819572 /  %% j10j15
\plot   15  .819572     20  .794579 /  %% j15j20
\plot   20  .794579     25  .7703483 /  %% j20j25
\plot   25  .7703483     30  .7468564 /  %% j25j30
\plot   30  .7468564     35  .7240809 /  %% j30j35
\plot   35  .7240809     40  .702 /  %% j35j40
\plot   40  .702     45  .6805924 /  %% j40j45
\plot   45  .6805924     50  .6598377 /  %% j45j50
\plot   50  .6598377     55  .6397159 /  %% j50j55
\plot   55  .6397159     60  .6202077 /  %% j55j60
\plot   60  .6202077     65  .6012943 /  %% j60j65
\plot   65  .6012943     70  .5829578 /  %% j65j70
\plot   70  .5829578     75  .5651804 /  %% j70j75
\plot   75  .5651804     80  .5479452 /  %% j75j80
\plot   80  .5479452     85  .5312355 /  %% j80j85
\plot   85  .5312355     90  .5150355 /  %% j85j90
\plot   90  .5150355     95  .4993294 /  %% j90j95
%% ... end of file  <isojdata.dat>
%%endSKIP
%————————————————————————
%%from mac-des.m
%% variable(x){-1}  (-1 )
%% variable(x2){x,advance(2)}  ( 1 )
%% point(h){x2,2.475}  ( 1 , 2.475 )
%% text(MAC){h}
\put {MAC} at  1  2.475
%% vertical diff = 0.29 units %% 0.28
%% variable(d){0.29}  ( .29 )
%% variable(h6){0.88}  ( .88 )  %0.9
%% text(\fbox{$0{\cdot}6$}){x,h6}
\put {\fbox{$0{\cdot}6$}} at -1  .88
%% variable(h8){h6,advance(d)}  ( 1.17 )
%% text(\fbox{$0{\cdot}8$}){x,h8}
\put {\fbox{$0{\cdot}8$}} at -1  1.17
%% variable(h10){h8,advance(d)}  ( 1.46 )
%% text(\fbox{$1{\cdot}0$}){x,h10}
\put {\fbox{$1{\cdot}0$}} at -1  1.46
%% variable(h12){h10,advance(d)}  ( 1.75 )
%% text(\fbox{$1{\cdot}2$}){x,h12}
\put {\fbox{$1{\cdot}2$}} at -1  1.75
%% variable(h14){h12,advance(d)}  ( 2.04 )
%% text(\fbox{$1{\cdot}4$}){x,h14}
\put {\fbox{$1{\cdot}4$}} at -1  2.04
%% variable(h16){h14,advance(d)}  ( 2.33 )
%% text(\fbox{$1{\cdot}6$}){x,h16}
\put {\fbox{$1{\cdot}6$}} at -1  2.33
%-------------------------
\newcommand{\myleft}{%
%\framebox{
\begin{minipage}{29mm}\centering%
  End-expired (\%)\\%
  in 100\% \\%
  oxygen\\
\end{minipage}%
%\ }%
  }%
%% text(\myleft){-45, 2.0}
\put {\myleft} at -45  2
%------------------------------
\newcommand{\myrightb}{%
    %\fbox{%
      \begin{minipage}{4cm}%
      End-expired (\%) in\\
      67\%\hspace{8mm}50\%\\
      N$_2$O\hspace{7.5mm}N$_2$O
      \end{minipage}
%  }%
      }% end of newcommand
%% text(\myrightb){102, 2.657}[l]  %% was 2.6
\put {\myrightb} [l]  at  102  2.657
%------------------------------
\newcommand{\mybottom}{Age (years)}%
%% text(\mybottom){46, 0.15}
\put {\mybottom} at  46  .15
%%text(\copyright\ RWD Nickalls\ 2001){22,0.5}
%% text(\large ISOFLURANE){46, 2.7}  %% 80
\put {\large ISOFLURANE} at  46  2.7
%-----------------------------------
% draw horizontal dashed lines
%%\linethickness=0.4pt %% equivalent to {\tiny .}
\linethickness=0.6pt %% half way between tiny and normalsize
\setdashes
%% variable(x5){5}  ( 5 )  %% Left X value
%% variable(x6){100}  ( 100 )  %% Right X value
%% variable(y16){2.3523}  ( 2.3523 )
%% variable(y14){2.1523}  ( 2.1523 )
%% variable(y12){1.9523}  ( 1.9523 )
%% variable(y10){1.7523}  ( 1.7523 )
%% variable(y08){1.5523}  ( 1.5523 )
%% variable(y06){1.3523}  ( 1.3523 )
%% variable(y04){1.1523}  ( 1.1523 )
%% variable(y02){0.9523}  ( .9523 )  %% = 0.7523 + 0.2
%% variable(y00){0.7523}  ( .7523 )  %% = 0.7523
%% point(L16){x5,y16}  ( 5 , 2.3523 )
%% point(R16){x6,y16}  ( 100 , 2.3523 )
%% point(L14){x5,y14}  ( 5 , 2.1523 )
%% point(R14){x6,y14}  ( 100 , 2.1523 )
%% point(L12){x5,y12}  ( 5 , 1.9523 )
%% point(R12){x6,y12}  ( 100 , 1.9523 )
%% point(L10){x5,y10}  ( 5 , 1.7523 )
%% point(R10){x6,y10}  ( 100 , 1.7523 )
%% point(L08){x5,y08}  ( 5 , 1.5523 )
%% point(R08){x6,y08}  ( 100 , 1.5523 )
%% point(L06){x5,y06}  ( 5 , 1.3523 )
%% point(R06){x6,y06}  ( 100 , 1.3523 )
%% point(L04){x5,y04}  ( 5 , 1.1523 )
%% point(R04){x6,y04}  ( 100 , 1.1523 )
%% point(L02){x5,y02}  ( 5 , .9523 )
%% point(R02){x6,y02}  ( 100 , .9523 )
%% point(L00){x5,y00}  ( 5 , .7523 )
%% point(R00){x6,y00}  ( 100 , .7523 )
%% draw the dashes from Left to Right
%% (so have small gap at right axis)
%% drawline(L16R16,L14R14,L12R12,L10R10,L08R08,L06R06,L04R04,L02R02,L00R00)
\putrule from  5  2.3523 to  100  2.3523  %% L16R16
\putrule from  5  2.1523 to  100  2.1523  %% L14R14
\putrule from  5  1.9523 to  100  1.9523  %% L12R12
\putrule from  5  1.7523 to  100  1.7523  %% L10R10
\putrule from  5  1.5523 to  100  1.5523  %% L08R08
\putrule from  5  1.3523 to  100  1.3523  %% L06R06
\putrule from  5  1.1523 to  100  1.1523  %% L04R04
\putrule from  5  .9523 to  100  .9523  %% L02R02
\putrule from  5  .7523 to  100  .7523  %% L00R00
\endpicture
\ } %framebox
\end{document}
%* ------------------------------------------------------------------------
%* PointNumber = 200
%* Number of points/variables used = 153
%* ----------------------------------------
```

6.3.3 Final mathsPIC program for making the charts

This version of the mathsPIC program (`mac-iso8t.m`) incorporated axis legend rotation (using LaTeX and PostScript), and generated the version used by the *Oxford handbook of anaesthesia*.

```
%% mac-iso8T.m (TEST version modified from mac-iso8.m)
%% Jan 10, 2006
%% mathsPICperl  version
%% final graph/chart for the bja
%% wih decimals ($\cdot$) and \fbox{}
%% new curves for anaesthesia
% mathsPIC

%% to test rotation legend on axes
%%----------------------
%% \\$---> $
%%  \\% ---\% for percent
%% enter the Y2 Y1 values in ET units
%% adjust \oddsidemargin
%% ? adjust linethickness
%% adjust minipage-->3.6cm
%% adjust possn of MAC
%% remove isoflurane word from ylegend
%% push Isoflutane title up
%% push age down

%%------------------
\documentclass[a4paper,12pt]{article}
\usepackage{mathspic}
\usepackage{decimal,rotating}

\begin{document}
% \oddsidemargin=-17mm
%%\framebox{%
\beginpicture
%-------------------

%% use sf font for figures for BJA
\fontfamily{cmss}\selectfont\normalsize
\linethickness=1.1pt %% = normalsize  (was 0.9 for BJA) (my manual p 23)

     %% structure copied from mac-des.m
%%--------
%% ISOflurane Delta for N2O = 0.75 = (66.6666/104)*1.17
%% y units = 12cm/2.2 = 5.454545
%paper{units(mm,5.454545cm) xrange(-5,100) yrange(0.4,2.6) axes(L) ticks(10,0.2)}
 paper{units(0.7mm,3.818181cm) xrange(-8,100) yrange(0.4,2.6)}

%-------------------
%% want to print only some of the L axis scale (0.6-2.4), so do it manually
\axis left
\     ticks withvalues     0{$\cdot$}6   0{$\cdot$}8  1{$\cdot$}0   1{$\cdot$}2   1{$\cdot$}4   1{$\cdot$}6
\            1{$\cdot$}8  2{$\cdot$}0   2{$\cdot$}2   2{$\cdot$}4  /
\            at   0.60   0.80   1.00   1.20   1.40
\            1.60   1.80   2.00  2.20   2.40    / /
%--------------------------
\axis bottom
\  ticks withvalues  0  10  20  30  40  50  60  70  80  90  100 /
\  at                0  10  20  30  40  50  60  70  80  90  100 / /
%------------------------------
\axis right
%%%    {using N2O  67%}}  shift = 0.7523
\     ticks withvalues   0    0{$\cdot$}2   0{$\cdot$}4   0{$\cdot$}6
\                        0{$\cdot$}8  1{$\cdot$}0  1{$\cdot$}2   1{$\cdot$}4
\                        1{$\cdot$}6  /
\           at 0.7523  0.9523  1.1523  1.3523  1.5523  1.7523  1.9523  2.1523
\                2.3523 / /

%----------------------------------------
%% extra 50% right axis  shift = 0.5614
%% since this axis is off the graph then need new paper command
%% but do not use axis() option
paper{units(0.7mm,3.818181cm) xrange(-8,121) yrange(0.5614,2.3614) }
\axis right   %% seconds right axis for 50% oxygen  shift = 0.5614
\     ticks withvalues   0     0{$\cdot$}2     0{$\cdot$}4     0{$\cdot$}6     0{$\cdot$}8
\     1{$\cdot$}0     1{$\cdot$}2     1{$\cdot$}4     1{$\cdot$}6   1{$\cdot$}8 /
\                     at 0.5614   0.7614   0.9614    1.1614    1.3614
\     1.5614  1.7614  1.9614   2.1614  2.3614  / /
%----------------------------------------

%%beginSKIP
\newcommand{\thickline}{\setplotsymbol({\Large .})}%
%\newcommand{\thinline}{\setplotsymbol({\tiny .})}%  = BJA graphs
%% make thin line a bit thicker for the OUP graphs
\newcommand{\thinline}{\setplotsymbol({\large .})}%

\thickline%
inputfile(isoqdata8.dat)   %1.6
\thinline%
inputfile(isopdata8.dat)   %1.4
\thickline%
inputfile(isondata8.dat)  % 1.2
\thinline%
inputfile(isomdata8.dat)  % 1
\thickline%
inputfile(isokdata8.dat)  % 0.8
\thinline%
inputfile(isojdata8.dat)   %0.6
%%endSKIP
```

```
%------------------------------------------
%%from mac-des.m
var  x=-1
var  x2=x + 2
point(h){x2,2.55}%   2.475
text(MAC){h}
%% vertical diff = 0.29 units %% 0.28
var  d=0.29

var  h6=0.88
text(\fbox{$0{\cdot}6$}){x,h6}

var  h8=h6+d
text(\fbox{$0{\cdot}8$}){x,h8}

var  h10=h8 + d
text(\fbox{$1{\cdot}0$}){x,h10}

var  h12=h10 +d
text(\fbox{$1{\cdot}2$}){x,h12}

var  h14 = h12+d
text(\fbox{$1{\cdot}4$}){x,h14}

var  h16=h14 +d
text(\fbox{$1{\cdot}6$}){x,h16}

%%=======new rotated legends from macATdes2.pl====================
var y2=2.6
var y1=0.4

%---------------------------
\newcommand{\ylegend}{\sf End-tidal (\%) in 100\,\% oxygen/air}%
%----determine string length ---> Yunits etc--------
\newlength{\ylength}%
\settowidth{\ylength}{\ylegend}%
%%%text(answer ylength = \number\ylength){37,-0.4}
%% halflength/3.818=0.777 y units %%
text(\turnbox{90}{\ylegend}){-25, y1+((y2-y1)/2) - 0.777}
%-------------------

beginSKIP
%-------------------
\newcommand{\rightylegend}{\sf End-tidal (\%) in N$_2$O}\%
\newlength{\rylength}%
\settowidth{\rylength}{\rightylegend}%
text(answer rylength = \number\rylength){37,-1.0}
%% halflength/3.818=0.7188 y units %%
text(\turnbox{270}{\rightylegend}){140, y1+((y2-y1)/2) + 0.7188}
%
endSKIP
```

```
%%================================
beginSKIP
%--------------------------
\newcommand{\myleft}{%
%\framebox{
\begin{minipage}{29mm}\centering%
\ End-expired (\%)\\%
\ in 100\% \\%
\ oxygen\\
\end{minipage}%
%\ }%
\ }%

text(\myleft){-45, 2.0}
endSKIP
%-------------------------------
\newcommand{\myrightb}{%
    %\fbox{%
\    \begin{minipage}{3.5cm}%  3.8cm
\    End-expired (\%) in\\
\    \hspace*{9mm}67\%\hspace{8mm}50\%\\
\    \hspace*{9mm}N$_2$O\hspace{7.5mm}N$_2$O
\    \end{minipage}
%  }%
\    }% end of newcommand
text(\myrightb){89.143, 2.657}[l]
%--------------------------------

%%\   End-expired (\%) in\\
%%\   67\%\hspace{8mm}50\%\\
%%\   N$_2$O\hspace{7.5mm}N$_2$O


%%========================


\newcommand{\mybottom}{Age (years)}%
text(\mybottom){46, 0.12} % 0.15

text({\footnotesize\copyright\ RWD Nickalls\ 2003}){19,0.5}

text(\large ISOFLURANE){46, 2.8}  %% 80

%-----------------------------------
% draw horizontal dashed lines
%%\linethickness=0.4pt %% equivalent to {\tiny .}
\linethickness=0.6pt %% half way between tiny and normalsize
\setdashes
var  x5=5     %% Left X value
var  x6=100   %% Right X value
var  y16=2.3523
var  y14=2.1523
var  y12=1.9523
var  y10=1.7523
var  y08=1.5523
var  y06=1.3523
var  y04=1.1523
var  y02=0.9523   %% = 0.7523 + 0.2
var  y00=0.7523   %% = 0.7523

point(L16){x5, y16}
point(R16){x6, y16}

point(L14){x5, y14}
point(R14){x6, y14}

point(L12){x5, y12}
point(R12){x6, y12}

point(L10){x5, y10}
point(R10){x6, y10}

point(L08){x5, y08}
point(R08){x6, y08}

point(L06){x5, y06}
point(R06){x6, y06}

point(L04){x5, y04}
point(R04){x6, y04}

point(L02){x5, y02}
point(R02){x6, y02}

point(L00){x5, y00}
point(R00){x6, y00}

%% draw the dashes from Left to Right
%% (so have small gap at right axis)
drawline(L16R16, L14R14, L12R12, L10R10,L08R08, L06R06, L04R04, L02R02, L00R00)

\endpicture
%%\ } %framebox
\end{document}
```

6.3.4 Output `mac-iso8t.mt` code from the previous mathsPIC program

```
%* ---------------------------------------------------------------
%* mathspic (Perl version 1.00 Feb 14, 2005)
%* A filter program for use with PiCTeX
%* Copyright (c) 2005 A Syropoulos & RWD Nickalls
%* Command line: /usr/local/bin/mpic100.pl mac-iso8t.m
%* Input filename : mac-iso8t.m
%* Output filename: mac-iso8t.mt
%* Date & time: 2006/01/13    09:19:33
%* ---------------------------------------------
%% mac-iso8T.m (TEST version modified from mac-iso8.m)
%% Jan 10, 2006
%% mathsPICperl  version
%% final graph/chart for the bja
%% wih decimals ($\cdot$) and \fbox{}
%% new curves for anaesthesia
% mathsPIC
%% to test rotation legend on axes
%%-----------------
%% \\$--> $
%%  \\% --\% for percent
%% enter the Y2 Y1 values in ET units
%% adjust \oddsidemargin
%% ? adjust linethickness
%% adjust minipage-->3.6cm
%% adjust possn of MAC
%% remove isoflurane word from ylegend
%% push Isoflutane title up
%% push age down
%%-------------
\documentclass[a4paper,12pt]{article}
\usepackage{mathspic}
\usepackage{decimal,rotating}
\begin{document}
% \oddsidemargin=-17mm
%%\framebox{%
\beginpicture
%-------------
%% use sf font for figures for BJA
\fontfamily{cmss}\selectfont\normalsize
\linethickness=1.1pt %% = normalsize  (was 0.9 for BJA)
     (my manual p 23)
      %% structure copied from mac-des.m
%%-------
%% ISOflurane Delta for N2O = 0.75 = (66.6666/104)*1.17
%% y units = 12cm/2.2 = 5.454545
%paper{units(mm,5.454545cm) xrange(-5,100)
     yrange(0.4,2.6) axes(L) ticks(10,0.2)}
%% paper{units(0.7mm,3.818181cm) xrange(-8,100)
     yrange(0.4,2.6)}
\setcoordinatesystem units <0.7mm,3.818181cm>
\setplotarea x from -8.00000 to 100.00000, y from 0.40000
     to 2.60000
%-------------
%% want to print only some of the L axis scale (0.6-2.4),
     so do it manually
\axis left
       ticks withvalues     0{$\cdot$}6   0{$\cdot$}8
            1{$\cdot$}0   1{$\cdot$}2   1{$\cdot$}4
```

```
           1{$\cdot$}6
               1{$\cdot$}8  2{$\cdot$}0   2{$\cdot$}2   2{$\cdot$}4  /
              at   0.60   0.80   1.00   1.20   1.40
              1.60   1.80   2.00  2.20   2.40    / /
%---------------------------------
\axis bottom
   ticks withvalues  0  10  20  30  40  50  60  70  80  90  100 /
   at                0  10  20  30  40  50  60  70  80  90  100 / /
%---------------------------------
\axis right
%%%    {using N2O  67%}}  shift = 0.7523
      ticks withvalues   0   0{$\cdot$}2   0{$\cdot$}4   0{$\cdot$}6
                        0{$\cdot$}8  1{$\cdot$}0   1{$\cdot$}2   1{$\cdot$}4
                       1{$\cdot$}6  /
               at 0.7523   0.9523   1.1523   1.3523   1.5523   1.7523   1.9523  2.1523
                 2.3523  / /
%-----------------------------------------
%% extra 50% right axis  shift = 0.5614
%% since this axis is off the graph then need new paper command
%% but do not use axis() option
%% paper{units(0.7mm,3.818181cm) xrange(-8,121) yrange(0.5614,2.3614) }
\setcoordinatesystem units <0.7mm,3.818181cm>
\setplotarea x from -8.00000 to 121.00000, y from 0.56140 to 2.36140
\axis right   %% seconds right axis for 50% oxygen  shift = 0.5614
      ticks withvalues   0     0{$\cdot$}2     0{$\cdot$}4    0{$\cdot$}6     0{$\cdot$}8
      1{$\cdot$}0     1{$\cdot$}2     1{$\cdot$}4    1{$\cdot$}6  1{$\cdot$}8  /
                      at  0.5614  0.7614  0.9614   1.1614   1.3614
      1.5614  1.7614  1.9614   2.1614  2.3614  / /
%-----------------------------------------
%%beginSKIP
\newcommand{\thickline}{\setplotsymbol({\Large .})}%
%\newcommand{\thinline}{\setplotsymbol({\tiny .})}%  = BJA graphs
%% make thin line a bit thicker for the OUP graphs
\newcommand{\thinline}{\setplotsymbol({\large .})}%
\thickline%
%% inputfile(isoqdata8.dat)  %1.6
%% ... start of file <isoqdata8.dat> loop [1]
%%% Iteration number: 1
%% q= mac40(iso) *  1.6
%% point(q5){5,2.325176} %% manual      q5 = (5.00000, 2.32518)
%% point(q10){10,2.25427}         q10 = (10.00000, 2.25427)
%% point(q15){15,2.185525}        q15 = (15.00000, 2.18553)
%% point(q20){20,2.118877}        q20 = (20.00000, 2.11888)
%% point(q25){25,2.054262}        q25 = (25.00000, 2.05426)
%% point(q30){30,1.991617}        q30 = (30.00000, 1.99162)
%% point(q35){35,1.930882}        q35 = (35.00000, 1.93088)
%% point(q40){40,1.872}           q40 = (40.00000, 1.87200)
%% point(q45){45,1.814913}        q45 = (45.00000, 1.81491)
%% point(q50){50,1.759567}        q50 = (50.00000, 1.75957)
%% point(q55){55,1.705909}        q55 = (55.00000, 1.70591)
%% point(q60){60,1.653887}        q60 = (60.00000, 1.65389)
%% point(q65){65,1.603451}        q65 = (65.00000, 1.60345)
%% point(q70){70,1.554554}        q70 = (70.00000, 1.55455)
%% point(q75){75,1.507148}        q75 = (75.00000, 1.50715)
%% point(q80){80,1.461187}        q80 = (80.00000, 1.46119)
%% point(q85){85,1.416628}        q85 = (85.00000, 1.41663)
%% point(q90){90,1.373428}        q90 = (90.00000, 1.37343)
%% point(q95){95,1.331545}        q95 = (95.00000, 1.33154)
%% drawline(q5 q10 q15 q20 q25 q30 q35 q40 q45 q50 q55 q60 q65 q70 q75 q80 q85 q90 q95)
\plot 5.00000 2.32518   10.00000 2.25427 / %% q5q10
\plot 10.00000 2.25427  15.00000 2.18553 / %% q10q15
\plot 15.00000 2.18553  20.00000 2.11888 / %% q15q20
\plot 20.00000 2.11888  25.00000 2.05426 / %% q20q25
\plot 25.00000 2.05426  30.00000 1.99162 / %% q25q30
\plot 30.00000 1.99162  35.00000 1.93088 / %% q30q35
\plot 35.00000 1.93088  40.00000 1.87200 / %% q35q40
\plot 40.00000 1.87200  45.00000 1.81491 / %% q40q45
\plot 45.00000 1.81491  50.00000 1.75957 / %% q45q50
\plot 50.00000 1.75957  55.00000 1.70591 / %% q50q55
\plot 55.00000 1.70591  60.00000 1.65389 / %% q55q60
\plot 60.00000 1.65389  65.00000 1.60345 / %% q60q65
\plot 65.00000 1.60345  70.00000 1.55455 / %% q65q70
\plot 70.00000 1.55455  75.00000 1.50715 / %% q70q75
\plot 75.00000 1.50715  80.00000 1.46119 / %% q75q80
\plot 80.00000 1.46119  85.00000 1.41663 / %% q80q85
\plot 85.00000 1.41663  90.00000 1.37343 / %% q85q90
\plot 90.00000 1.37343  95.00000 1.33154 / %% q90q95
%% drawpoint(q10  q20  q30  q40  q50  q60  q70  q80  q90)
\put {$\bullet$} at 10.00000 2.25427 %% q10
\put {$\bullet$} at 20.00000 2.11888 %% q20
\put {$\bullet$} at 30.00000 1.99162 %% q30
\put {$\bullet$} at 40.00000 1.87200 %% q40
\put {$\bullet$} at 50.00000 1.75957 %% q50
\put {$\bullet$} at 60.00000 1.65389 %% q60
\put {$\bullet$} at 70.00000 1.55455 %% q70
\put {$\bullet$} at 80.00000 1.46119 %% q80
\put {$\bullet$} at 90.00000 1.37343 %% q90
%% ... end of file <isoqdata8.dat> loop [1]
\thinline%
%% inputfile(isopdata8.dat)  %1.4
%% ...  start of file <isopdata8.dat> loop [1]
```

```
%%% Iteration number: 1
%% p= mac40(iso) *  1.4
%% point(p5){5,2.034529}  %% manual      p5 = (5.00000, 2.03453)
%% point(p10){10,1.972486}       p10 = (10.00000, 1.97249)
%% point(p15){15,1.912335}       p15 = (15.00000, 1.91233)
%% point(p20){20,1.854018}       p20 = (20.00000, 1.85402)
%% point(p25){25,1.797479}       p25 = (25.00000, 1.79748)
%% point(p30){30,1.742665}       p30 = (30.00000, 1.74266)
%% point(p35){35,1.689522}       p35 = (35.00000, 1.68952)
%% point(p40){40,1.638}          p40 = (40.00000, 1.63800)
%% point(p45){45,1.588049}       p45 = (45.00000, 1.58805)
%% point(p50){50,1.539621}       p50 = (50.00000, 1.53962)
%% point(p55){55,1.49267}        p55 = (55.00000, 1.49267)
%% point(p60){60,1.447151}       p60 = (60.00000, 1.44715)
%% point(p65){65,1.40302}        p65 = (65.00000, 1.40302)
%% point(p70){70,1.360235}       p70 = (70.00000, 1.36024)
%% point(p75){75,1.318754}       p75 = (75.00000, 1.31875)
%% point(p80){80,1.278539}       p80 = (80.00000, 1.27854)
%% point(p85){85,1.23955}        p85 = (85.00000, 1.23955)
%% point(p90){90,1.201749}       p90 = (90.00000, 1.20175)
%% point(p95){95,1.165102}       p95 = (95.00000, 1.16510)
%% drawline(p5 p10 p15 p20 p25 p30 p35 p40 p45 p50 p55 p60 p65 p70 p75 p80 p85 p90 p95)
\plot 5.00000 2.03453   10.00000 1.97249 / %% p5p10
\plot 10.00000 1.97249  15.00000 1.91233 / %% p10p15
\plot 15.00000 1.91233  20.00000 1.85402 / %% p15p20
\plot 20.00000 1.85402  25.00000 1.79748 / %% p20p25
\plot 25.00000 1.79748  30.00000 1.74266 / %% p25p30
\plot 30.00000 1.74266  35.00000 1.68952 / %% p30p35
\plot 35.00000 1.68952  40.00000 1.63800 / %% p35p40
\plot 40.00000 1.63800  45.00000 1.58805 / %% p40p45
\plot 45.00000 1.58805  50.00000 1.53962 / %% p45p50
\plot 50.00000 1.53962  55.00000 1.49267 / %% p50p55
\plot 55.00000 1.49267  60.00000 1.44715 / %% p55p60
\plot 60.00000 1.44715  65.00000 1.40302 / %% p60p65
\plot 65.00000 1.40302  70.00000 1.36024 / %% p65p70
\plot 70.00000 1.36024  75.00000 1.31875 / %% p70p75
\plot 75.00000 1.31875  80.00000 1.27854 / %% p75p80
\plot 80.00000 1.27854  85.00000 1.23955 / %% p80p85
\plot 85.00000 1.23955  90.00000 1.20175 / %% p85p90
\plot 90.00000 1.20175  95.00000 1.16510 / %% p90p95
%% ... end of file <isopdata8.dat> loop [1]
\thickline%
%% inputfile(isondata8.dat)  % 1.2
%% ... start of file <isondata8.dat> loop [1]
%%% Iteration number: 1
%% n= mac40(iso) *  1.2
%% point(n5){5,1.743882}  %% manual      n5 = (5.00000, 1.74388)
%% point(n10){10,1.690702}       n10 = (10.00000, 1.69070)
%% point(n15){15,1.639144}       n15 = (15.00000, 1.63914)
%% point(n20){20,1.589158}       n20 = (20.00000, 1.58916)
%% point(n25){25,1.540697}       n25 = (25.00000, 1.54070)
%% point(n30){30,1.493713}       n30 = (30.00000, 1.49371)
%% point(n35){35,1.448162}       n35 = (35.00000, 1.44816)
%% point(n40){40,1.404}          n40 = (40.00000, 1.40400)
%% point(n45){45,1.361185}       n45 = (45.00000, 1.36119)
%% point(n50){50,1.319675}       n50 = (50.00000, 1.31967)
%% point(n55){55,1.279432}       n55 = (55.00000, 1.27943)
%% point(n60){60,1.240415}       n60 = (60.00000, 1.24042)
%% point(n65){65,1.202589}       n65 = (65.00000, 1.20259)
%% point(n70){70,1.165916}       n70 = (70.00000, 1.16592)
%% point(n75){75,1.130361}       n75 = (75.00000, 1.13036)
%% point(n80){80,1.09589}        n80 = (80.00000, 1.09589)
%% point(n85){85,1.062471}       n85 = (85.00000, 1.06247)
%% point(n90){90,1.030071}       n90 = (90.00000, 1.03007)
%% point(n95){95,0.9986587}      n95 = (95.00000, 0.99866)
%% drawline(n5 n10 n15 n20 n25 n30 n35 n40 n45 n50 n55 n60
     n65 n70 n75 n80 n85 n90 n95)
\plot 5.00000 1.74388   10.00000 1.69070 / %% n5n10
\plot 10.00000 1.69070  15.00000 1.63914 / %% n10n15
\plot 15.00000 1.63914  20.00000 1.58916 / %% n15n20
\plot 20.00000 1.58916  25.00000 1.54070 / %% n20n25
\plot 25.00000 1.54070  30.00000 1.49371 / %% n25n30
\plot 30.00000 1.49371  35.00000 1.44816 / %% n30n35
\plot 35.00000 1.44816  40.00000 1.40400 / %% n35n40
\plot 40.00000 1.40400  45.00000 1.36119 / %% n40n45
\plot 45.00000 1.36119  50.00000 1.31967 / %% n45n50
\plot 50.00000 1.31967  55.00000 1.27943 / %% n50n55
\plot 55.00000 1.27943  60.00000 1.24042 / %% n55n60
\plot 60.00000 1.24042  65.00000 1.20259 / %% n60n65
\plot 65.00000 1.20259  70.00000 1.16592 / %% n65n70
\plot 70.00000 1.16592  75.00000 1.13036 / %% n70n75
\plot 75.00000 1.13036  80.00000 1.09589 / %% n75n80
\plot 80.00000 1.09589  85.00000 1.06247 / %% n80n85
\plot 85.00000 1.06247  90.00000 1.03007 / %% n85n90
\plot 90.00000 1.03007  95.00000 0.99866 / %% n90n95
%% drawpoint(n10  n20  n30 n40 n50 n60 n70 n80 n90)
\put {$\bullet$} at 10.00000 1.69070 %% n10
\put {$\bullet$} at 20.00000 1.58916 %% n20
\put {$\bullet$} at 30.00000 1.49371 %% n30
\put {$\bullet$} at 40.00000 1.40400 %% n40
\put {$\bullet$} at 50.00000 1.31967 %% n50
\put {$\bullet$} at 60.00000 1.24042 %% n60
\put {$\bullet$} at 70.00000 1.16592 %% n70
\put {$\bullet$} at 80.00000 1.09589 %% n80
\put {$\bullet$} at 90.00000 1.03007 %% n90
%% ... end of file <isondata8.dat> loop [1]
\thinline%
%% inputfile(isomdata8.dat)  % 1
%% ...  start of file <isomdata8.dat> loop [1]
%%% Iteration number: 1
%% m= mac40(iso) *  1
%% point(m5){5,  1.453235}       m5 = (5.00000, 1.45324)
%% point(m10){10,1.408918}       m10 = (10.00000, 1.40892)
%% point(m15){15,1.365953}       m15 = (15.00000, 1.36595)
%% point(m20){20,1.324298}       m20 = (20.00000, 1.32430)
%% point(m25){25,1.283914}       m25 = (25.00000, 1.28391)
%% point(m30){30,1.244761}       m30 = (30.00000, 1.24476)
%% point(m35){35,1.206802}       m35 = (35.00000, 1.20680)
%% point(m40){40,1.17}  m40 = (40.00000, 1.17000)
%% point(m45){45,1.134321}       m45 = (45.00000, 1.13432)
%% point(m50){50,1.099729}       m50 = (50.00000, 1.09973)
%% point(m55){55,1.066193}       m55 = (55.00000, 1.06619)
%% point(m60){60,1.033679}       m60 = (60.00000, 1.03368)
%% point(m65){65,1.002157}       m65 = (65.00000, 1.00216)
%% point(m70){70,0.9715963}      m70 = (70.00000, 0.97160)
%% point(m75){75,0.9419674}      m75 = (75.00000, 0.94197)
%% point(m80){80,0.9132419}      m80 = (80.00000, 0.91324)
%% point(m85){85,0.8853925}      m85 = (85.00000, 0.88539)
%% point(m90){90,0.8583924}      m90 = (90.00000, 0.85839)
%% point(m95){95,0.8322156}      m95 = (95.00000, 0.83222)
%% drawline(m5 m10 m15 m20 m25 m30 m35 m40 m45 m50 m55 m60 m65 m70 m75 m80 m85 m90 m95)
\plot 5.00000 1.45324   10.00000 1.40892 / %% m5m10
\plot 10.00000 1.40892  15.00000 1.36595 / %% m10m15
\plot 15.00000 1.36595  20.00000 1.32430 / %% m15m20
\plot 20.00000 1.32430  25.00000 1.28391 / %% m20m25
\plot 25.00000 1.28391  30.00000 1.24476 / %% m25m30
\plot 30.00000 1.24476  35.00000 1.20680 / %% m30m35
\plot 35.00000 1.20680  40.00000 1.17000 / %% m35m40
\plot 40.00000 1.17000  45.00000 1.13432 / %% m40m45
\plot 45.00000 1.13432  50.00000 1.09973 / %% m45m50
\plot 50.00000 1.09973  55.00000 1.06619 / %% m50m55
\plot 55.00000 1.06619  60.00000 1.03368 / %% m55m60
\plot 60.00000 1.03368  65.00000 1.00216 / %% m60m65
\plot 65.00000 1.00216  70.00000 0.97160 / %% m65m70
\plot 70.00000 0.97160  75.00000 0.94197 / %% m70m75
\plot 75.00000 0.94197  80.00000 0.91324 / %% m75m80
\plot 80.00000 0.91324  85.00000 0.88539 / %% m80m85
\plot 85.00000 0.88539  90.00000 0.85839 / %% m85m90
\plot 90.00000 0.85839  95.00000 0.83222 / %% m90m95
%% ... end of file <isomdata8.dat> loop [1]
\thickline%
%% inputfile(isokdata8.dat)  % 0.8
%% ...  start of file <isokdata8.dat> loop [1]
%%% Iteration number: 1
%% k= mac40(iso) *   .8
%% point(k5){5,1.162588} %% manual       k5 = (5.00000, 1.16259)
%% point(k10){10,1.127135}       k10 = (10.00000, 1.12713)
%% point(k15){15,1.092763}       k15 = (15.00000, 1.09276)
%% point(k20){20,1.059439}       k20 = (20.00000, 1.05944)
%% point(k25){25,1.027131}       k25 = (25.00000, 1.02713)
%% point(k30){30,0.9958085}      k30 = (30.00000, 0.99581)
%% point(k35){35,0.9654412}      k35 = (35.00000, 0.96544)
%% point(k40){40,0.936}          k40 = (40.00000, 0.93600)
%% point(k45){45,0.9074566}      k45 = (45.00000, 0.90746)
%% point(k50){50,0.8797836}      k50 = (50.00000, 0.87978)
%% point(k55){55,0.8529544}      k55 = (55.00000, 0.85295)
%% point(k60){60,0.8269435}      k60 = (60.00000, 0.82694)
%% point(k65){65,0.8017257}      k65 = (65.00000, 0.80173)
%% point(k70){70,0.7772771}      k70 = (70.00000, 0.77728)
%% point(k75){75,0.7535739}      k75 = (75.00000, 0.75357)
%% point(k80){80,0.7305936}      k80 = (80.00000, 0.73059)
%% point(k85){85,0.708314}       k85 = (85.00000, 0.70831)
%% point(k90){90,0.6867139}      k90 = (90.00000, 0.68671)
%% point(k95){95,0.6657725}      k95 = (95.00000, 0.66577)
%% drawline(k5 k10 k15 k20 k25 k30 k35 k40 k45 k50 k55 k60 k65 k70 k75 k80 k85 k90 k95)
\plot 5.00000 1.16259   10.00000 1.12713 / %% k5k10
\plot 10.00000 1.12713  15.00000 1.09276 / %% k10k15
\plot 15.00000 1.09276  20.00000 1.05944 / %% k15k20
\plot 20.00000 1.05944  25.00000 1.02713 / %% k20k25
\plot 25.00000 1.02713  30.00000 0.99581 / %% k25k30
\plot 30.00000 0.99581  35.00000 0.96544 / %% k30k35
\plot 35.00000 0.96544  40.00000 0.93600 / %% k35k40
\plot 40.00000 0.93600  45.00000 0.90746 / %% k40k45
\plot 45.00000 0.90746  50.00000 0.87978 / %% k45k50
\plot 50.00000 0.87978  55.00000 0.85295 / %% k50k55
\plot 55.00000 0.85295  60.00000 0.82694 / %% k55k60
\plot 60.00000 0.82694  65.00000 0.80173 / %% k60k65
\plot 65.00000 0.80173  70.00000 0.77728 / %% k65k70
\plot 70.00000 0.77728  75.00000 0.75357 / %% k70k75
\plot 75.00000 0.75357  80.00000 0.73059 / %% k75k80
\plot 80.00000 0.73059  85.00000 0.70831 / %% k80k85
\plot 85.00000 0.70831  90.00000 0.68671 / %% k85k90
\plot 90.00000 0.68671  95.00000 0.66577 / %% k90k95
%% drawpoint(k10  k20 k30 k40 k50 k60 k70 k80 k90)
\put {$\bullet$} at 10.00000 1.12713 %% k10
\put {$\bullet$} at 20.00000 1.05944 %% k20
\put {$\bullet$} at 30.00000 0.99581 %% k30
\put {$\bullet$} at 40.00000 0.93600 %% k40
\put {$\bullet$} at 50.00000 0.87978 %% k50
\put {$\bullet$} at 60.00000 0.82694 %% k60
\put {$\bullet$} at 70.00000 0.77728 %% k70
\put {$\bullet$} at 80.00000 0.73059 %% k80
\put {$\bullet$} at 90.00000 0.68671 %% k90
%% ... end of file <isokdata8.dat> loop [1]
\thinline%
%% inputfile(isojdata8.dat)  %0.6
%% ... start of file <isojdata8.dat> loop [1]
%%% Iteration number: 1
%% j= mac40(iso) *  .6
%% point(j5){5,0.871941}  %% manual     j5 = (5.00000, 0.87194)
%% point(j10){10,0.8453511}      j10 = (10.00000, 0.84535)
%% point(j15){15,0.819572}       j15 = (15.00000, 0.81957)
%% point(j20){20,0.794579}       j20 = (20.00000, 0.79458)
%% point(j25){25,0.7703483}      j25 = (25.00000, 0.77035)
%% point(j30){30,0.7468564}      j30 = (30.00000, 0.74686)
%% point(j35){35,0.7240809}      j35 = (35.00000, 0.72408)
%% point(j40){40,0.702}          j40 = (40.00000, 0.70200)
%% point(j45){45,0.6805924}      j45 = (45.00000, 0.68059)
%% point(j50){50,0.6598377}      j50 = (50.00000, 0.65984)
%% point(j55){55,0.6397159}      j55 = (55.00000, 0.63972)
%% point(j60){60,0.6202077}      j60 = (60.00000, 0.62021)
%% point(j65){65,0.6012943}      j65 = (65.00000, 0.60129)
%% point(j70){70,0.5829578}      j70 = (70.00000, 0.58296)
%% point(j75){75,0.5651804}      j75 = (75.00000, 0.56518)
%% point(j80){80,0.5479452}      j80 = (80.00000, 0.54795)
%% point(j85){85,0.5312355}      j85 = (85.00000, 0.53124)
%% point(j90){90,0.5150355}      j90 = (90.00000, 0.51504)
%% point(j95){95,0.4993294}      j95 = (95.00000, 0.49933)
%% drawline(j5 j10 j15 j20 j25 j30 j35 j40 j45 j50 j55 j60
     j65 j70 j75 j80 j85 j90 j95)
\plot 5.00000 0.87194   10.00000 0.84535 / %% j5j10
\plot 10.00000 0.84535  15.00000 0.81957 / %% j10j15
\plot 15.00000 0.81957  20.00000 0.79458 / %% j15j20
\plot 20.00000 0.79458  25.00000 0.77035 / %% j20j25
\plot 25.00000 0.77035  30.00000 0.74686 / %% j25j30
\plot 30.00000 0.74686  35.00000 0.72408 / %% j30j35
\plot 35.00000 0.72408  40.00000 0.70200 / %% j35j40
\plot 40.00000 0.70200  45.00000 0.68059 / %% j40j45
\plot 45.00000 0.68059  50.00000 0.65984 / %% j45j50
\plot 50.00000 0.65984  55.00000 0.63972 / %% j50j55
\plot 55.00000 0.63972  60.00000 0.62021 / %% j55j60
\plot 60.00000 0.62021  65.00000 0.60129 / %% j60j65
\plot 65.00000 0.60129  70.00000 0.58296 / %% j65j70
\plot 70.00000 0.58296  75.00000 0.56518 / %% j70j75
\plot 75.00000 0.56518  80.00000 0.54795 / %% j75j80
\plot 80.00000 0.54795  85.00000 0.53124 / %% j80j85
\plot 85.00000 0.53124  90.00000 0.51504 / %% j85j90
\plot 90.00000 0.51504  95.00000 0.49933 / %% j90j95
%% ... end of file <isojdata8.dat> loop [1]
%%endSKIP
%--------------------------------------------------
%%from mac-des.m
%% var  x=-1
%% x = -1
%% var  x2=x + 2
%% x2 = 1
%% point(h){x2,2.55}%  2.475     h = (1.00000, 2.55000)
%% text(MAC){h}
\put {MAC} at 1.000000 2.550000
%% vertical diff = 0.29 units %% 0.28
%% var  d=0.29
%% d = 0.29
%% var  h6=0.88
%% h6 = 0.88
%% text(\fbox{$0{\cdot}6$}){x,h6}
\put {\fbox{$0{\cdot}6$}} at -1.000000 0.880000
%% var  h8=h6+d
%% h8 = 1.17
%% text(\fbox{$0{\cdot}8$}){x,h8}
\put {\fbox{$0{\cdot}8$}} at -1.000000 1.170000
%% var  h10=h8 + d
%% h10 = 1.46
%% text(\fbox{$1{\cdot}0$}){x,h10}
```

```
\put {\fbox{$1{\cdot}0$}} at -1.000000 1.460000
%% var  h12=h10 +d
%% h12 = 1.75
%% text(\fbox{$1{\cdot}2$}){x,h12}
\put {\fbox{$1{\cdot}2$}} at -1.000000 1.750000
%% var  h14 = h12+d
%% h14 = 2.04
%% text(\fbox{$1{\cdot}4$}){x,h14}
\put {\fbox{$1{\cdot}4$}} at -1.000000 2.040000
%% var  h16=h14 +d
%% h16 = 2.33
%% text(\fbox{$1{\cdot}6$}){x,h16}
\put {\fbox{$1{\cdot}6$}} at -1.000000 2.330000
%%=======new rotated legends from macATdes2.pl====================
%% var y2=2.6
%% y2 = 2.6
%% var y1=0.4
%% y1 = 0.4
%-----------------------------
\newcommand{\ylegend}{\sf End-tidal (\%) in 100\,\% oxygen/air}%
%----determine string length --> Yunits etc----------
\newlength{\ylength}%
\settowidth{\ylength}{\ylegend}%
%%%text(answer ylength = \number\ylength){37,-0.4}
%% halflength/3.818=0.777 y units %%
%% text(\turnbox{90}{\ylegend}){-25, y1+((y2-y1)/2) - 0.777}
\put {\turnbox{90}{\ylegend}} at -25.000000 0.723000
%--------------------
%%beginSKIP
%%endSKIP
%%===============================
%%beginSKIP
%%endSKIP
%-------------------------------------
\newcommand{\myrightb}{%
   %\fbox{%
     \begin{minipage}{3.5cm}%  3.8cm
     End-expired (\%) in\\
     \hspace*{9mm}67\%\hspace{8mm}50\%\\
     \hspace*{9mm}N$_2$O\hspace{7.5mm}N$_2$O
     \end{minipage}
%  }%
     }% end of newcommand
%% text(\myrightb){89.143, 2.657}[l]
\put {\myrightb} [l] at 89.143000 2.657000
%--------------------------------------
%%\  End-expired (\%) in\\
%%\  67\%\hspace{8mm}50\%\\
%%\  N$_2$O\hspace{7.5mm}N$_2$O
%%=======================
\newcommand{\mybottom}{Age (years)}%
```

```
%% text(\mybottom){46, 0.12} % 0.15
\put {\mybottom} at 46.000000 0.120000
%% text({\footnotesize\copyright\ RWD Nickalls\ 2003}){19,0.5}
\put {{\footnotesize\copyright\ RWD Nickalls\ 2003}} at 19.000000 0.500000
%% text(\large ISOFLURANE){46, 2.8}  %% 80
\put {\large ISOFLURANE} at 46.000000 2.800000
%-------------------------------
% draw horizontal dashed lines
%%\linethickness=0.4pt %% equivalent to {\tiny .}
\linethickness=0.6pt %% half way between tiny and normalsize
\setdashes
%% var  x5=5     %% Left X value
%% x5 = 5
%% var  x6=100   %% Right X value
%% x6 = 100
%% var  y16=2.3523
%% y16 = 2.3523
%% var  y14=2.1523
%% y14 = 2.1523
%% var  y12=1.9523
%% y12 = 1.9523
%% var  y10=1.7523
%% y10 = 1.7523
%% var  y08=1.5523
%% y08 = 1.5523
%% var  y06=1.3523
%% y06 = 1.3523
%% var  y04=1.1523
%% y04 = 1.1523
%% var  y02=0.9523   %% = 0.7523 + 0.2
%% y02 = 0.9523
%% var  y00=0.7523   %% = 0.7523
%% y00 = 0.7523
%% point(L16){x5, y16}  L16 = (5.00000, 2.35230)
%% point(R16){x6, y16}  R16 = (100.00000, 2.35230)
%% point(L14){x5, y14}  L14 = (5.00000, 2.15230)
%% point(R14){x6, y14}  R14 = (100.00000, 2.15230)
%% point(L12){x5, y12}  L12 = (5.00000, 1.95230)
%% point(R12){x6, y12}  R12 = (100.00000, 1.95230)
%% point(L10){x5, y10}  L10 = (5.00000, 1.75230)
%% point(R10){x6, y10}  R10 = (100.00000, 1.75230)
%% point(L08){x5, y08}  L08 = (5.00000, 1.55230)
%% point(R08){x6, y08}  R08 = (100.00000, 1.55230)
%% point(L06){x5, y06}  L06 = (5.00000, 1.35230)
%% point(R06){x6, y06}  R06 = (100.00000, 1.35230)
%% point(L04){x5, y04}  L04 = (5.00000, 1.15230)
%% point(R04){x6, y04}  R04 = (100.00000, 1.15230)
%% point(L02){x5, y02}  L02 = (5.00000, 0.95230)
%% point(R02){x6, y02}  R02 = (100.00000, 0.95230)
%% point(L00){x5, y00}  L00 = (5.00000, 0.75230)
%% point(R00){x6, y00}  R00 = (100.00000, 0.75230)
%% draw the dashes from Left to Right
%% (so have small gap at right axis)
%% drawline(L16R16, L14R14, L12R12, L10R10,L08R08, L06R06, L04R04, L02R02, L00R00)
\putrule from 5.00000 2.35230 to 100.00000 2.35230 %% L16R16
\putrule from 5.00000 2.15230 to 100.00000 2.15230 %% L14R14
\putrule from 5.00000 1.95230 to 100.00000 1.95230 %% L12R12
\putrule from 5.00000 1.75230 to 100.00000 1.75230 %% L10R10
\putrule from 5.00000 1.55230 to 100.00000 1.55230 %% L08R08
\putrule from 5.00000 1.35230 to 100.00000 1.35230 %% L06R06
\putrule from 5.00000 1.15230 to 100.00000 1.15230 %% L04R04
\putrule from 5.00000 0.95230 to 100.00000 0.95230 %% L02R02
\putrule from 5.00000 0.75230 to 100.00000 0.75230 %% L00R00
\endpicture
%%\ } %framebox
\end{document}
```

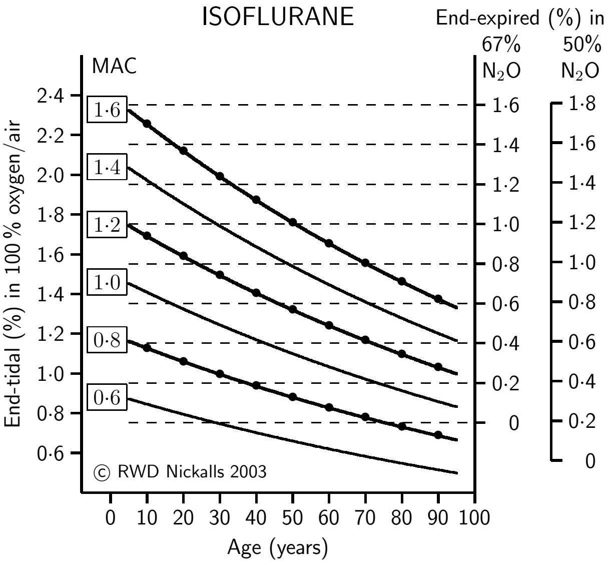


Figure 6.5: The isoflurane version (`mac-iso8t.m`) generated for the *Oxford Handbook of Anaesthesia* with rotated LHS-axis legend.

6.4 References

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  [A new bug-fix version: February 2007]

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Part II

The front-end coordinating program

Chapter 7

The Perl/Tk front-end

April 19, 2009 /aHOUSE/book-xenon/ch-tklauncher/

7.1 Introduction

The camomile program is currently launched by a Perl/Tk program which allows the user to launch the main camomile program, as well as the other associated components of the system (e.g. access the epidural and double-lumen tube database, print out the anaesthesia record etc). Clicking on the 'run camomile' button launches the co-ordinating program `launchcam12.pl` which launches the Camomile program itself.

```
 bash runcamomile.sh  (generates the widget <tklaunch2.pl>)
---> click on "RUN" button
---> perl launchcam12.pl  (runs the Camomile program)
---> at end of operation terminate program (click on "QUIT" menu option)
      ---> closes down screen and generates the widget again
      ---> click on "PRINT LAST CASE" button
           (generates  the paper and HTML Anaesthetic Record)
```

After the anaesthetic/operation we terminate the `launchcamXX.pl` program and control reverts to the launching widget, from which we can then start the post-processing of the collected data and hence generate the printed Anaesthesia Record. More recently, the Anaesthesia Record data and graphs have been conveniently coordinated via a HTML frontend which allows all the data, programs and graphs to be viewed easily.
The buttons are mapped to programs as follows:

- RUN (camomile) → `launchcam12.pl`
- EPIDURAL (database) → `epidural.pl`
- PROJECT TEAM → `camteana5dvi.dvi`
- QUIT → `exit()`
- PRINT LAST CASE (not active; just gives help message)

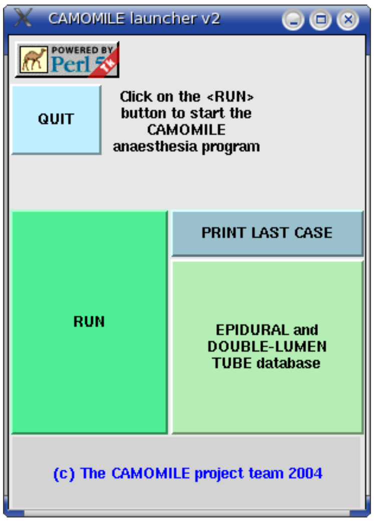

CAMOMILE launcher v2
POWERED BY Perl
QUIT
Click on the <RUN> button to start the CAMOMILE anaesthesia program
PRINT LAST CASE
RUN
EPIDURAL and DOUBLE-LUMEN TUBE database
(c) The CAMOMILE project team 2004

Figure 7.1:
Screen showing the initial graphic front-end (loader widget; `<tklaunch2.pl>`) which allows the user to either start the Camomile program, or access other utilities (e.g., process the data from last case, or run the Tube & EPIDural database program[a]—TEPID). Note that the program `<tklaunch2.pl>` is itself launched by the bash script `<runcamomile>`.

[a] Allows the user to search the TEPID database to determine the predicted tube length/size and epidural depth for a given patient, by inputting age, gender, height, weight.

7.2 The BASH script runcamomile

In practice, the graphic front-end is itself launched by the small BASH script `runcamomile`. The reason for using a preliminary script to launch the Perl/Tk program is because this allows the initial start-up size and position of the Tk widget to be easily controlled using the `-geometry` commandline option.

```
#!usr/bin/bash
# runcamomile.sh
## BASH script to change dir to —> /datexsim
## & start the loader widget
##———————
echo "changing directory to
    ~/allfiles/camomiletop/datexsim"
cd /home/dick/allfiles/camomiletop/datexsim/
perl ./tklaunch2.pl −geometry 300x400−50−300
```

Note that the opening size and position in the screen is set using the `-geometry` switch and its various options *width, height, x-shift, y-shift* (see Lidie and Walsh, 2002, p 409). The format for the `-geometry` switch is as follows[1]

[1] See the book: *Mastering Perl/Tk* by Lidie S and Walsh N (O'Reilly).

```
.... -geometry
    [width]x[height]{+|-}[x-shift]{+|-}[y-shift]
```

The sign option {+|-} determines the location of the origin of the screen coordinates. The − sign is associated with the position of the bottom right-hand corner of the widget relative to the bottom right-hand corner of the screen, and the + sign is associated with the top left-hand corner of the widget relative to the top left-hand corner of the screen.

In order to make the script function ‘globally’ (i.e. much as a DOS batch-file would), it first has its mode set to ‘executable’ using the Linux command

```
chmod u+x runcamomile
```

(which adds the ‘executable’ permission for the user), and then the script (which must have no file extension) is placed in the $PATH, which in the case of a Linux ‘user’s’ batch-file means that it is placed in the standard directory /usr/local/bin/ (which is always in the Linux $PATH), i.e.

```
/usr/local/bin/runcamomile
```

Now, whichever directory the user types the command runcamomile in, then Linux will move to the .../datexsim directory and run the tklaunch2.pl program.

7.3 Pressing the “RUN” button

The subroutine and code which starts the Camomile program is as follows: Clicking on one of the button first deletes the screen widget (to prevent another button being pressed), calls the associated program or message widget, and finally restores the screen widget when the launched program terminates. For example pressing the ‘RUN’ button launches the perl program launchcam12.pl by calling the subroutine launch() as follows.

```
sub launch {
    if (-e "launchcam12.pl")
       {# first remove the Tk screen
          $topwindow ->destroy if Tk::Exists($topwindow);
        # now launch the program
          system("perl ./launchcam12.pl");
        # reinstate the widget when the program terminates
          system ("perl ./tklaunch2.pl -geometry
              300x400-50-300")}
        else{print "....ERROR:\n";
             print "....can't find program
                 <launchcam12.pl>\n\n";exit()}
        }
```

7.3.1 Program: `tklaunch2.pl`

The widget program uses the perl Tk module, and the associated `Tk::DialogBox`. Note that the nice Perl5/Tk logo is the image `anim.gif` which can be found at the following direcctory. `/usr/lib/perl5/vendor_perl/5.8.1/i386-linux-thread-multi/Tk/`

```perl
#!/usr/bin/perl -w
## /allfiles/camomiletop/datexsim/thlaunch2.pl
## RWD Nickalls  April 5, 2004
## to get FullScreen mode at startup (p 307)
##-------------------------
use Tk;
use Tk::DialogBox;

$topwindow = MainWindow -> new();
#------------------------------
$dialog1 = $topwindow -> DialogBox( -title => "STATUS",
                                     -buttons => ["OK"]);
$dialog1 ->add("Label",
                          -text => "The PRINT option is not enabled just now.
                           However, in due course the PRINT button will coordinate
                           printing out of all the sheets from the last operation",
                          -wraplength =>400)
         ->pack();
##------------------------------------
$topwindow -> title("Launch CAMOMILE");
$topwindow -> Label(-text => "Click on the <RUN> button to start the CAMOMILE
                                   anaesthesia program",
                       -wraplength =>130,
                       -padx => 250,
                       -height => 10 )
              -> pack();
##------------------------------------
## camel logo button
## /usr/lib/perl5/vendor_perl/5.8.1/i386-linux-thread-multi/Tk/
$camelimage = $topwindow -> Photo(-file => '/home/dick/allfiles/camomiletop/datexsim/anim.gif');
$topwindow -> Button(-relief => 'flat', -image => $camelimage)
              -> place(-relx=>0, -rely=>0);
##------------------------------------
## project team button
$topwindow -> Button(-text => "(c) The CAMOMILE project team 2004",
                          -padx =>30, -pady =>20, -relief => 'flat',
                          -background => 'LightGrey',
                          -activebackground =>'Grey',
                       -foreground => 'Blue',
                       -command => \&projectteam )
                      ->pack(-side => 'bottom',-expand =>1);
##-----------------------------------
# RUN button
$topwindow -> Button (-text     => "RUN",
                       -padx    => 50, -pady => 90,
                       -relief => 'raised',
                      -background => 'SeaGreen1',
                      -activebackground =>'SeaGreen2',
                      -command => \&launch)
            ->pack(-side => 'left', -expand => 1);
##-----------------------------------
# QUIT button
$topwindow  -> Button (-text     => "QUIT",
                      -padx => 20, -pady => 20,
                      -relief => 'raised',
                      -background => 'LightBlue1',
                      -activebackground =>'LightBlue2',
                      -command => \&quit )
           -> place(-relx=>0, -rely=>0.1);
           #-> pack(-side =>'left', -expand => 1);
##-----------------------------------
# EPIDURAL button
$topwindow  -> Button (-text     => "EPIDURAL and DOUBLE-LUMEN TUBE database",
                         -wraplength =>110,
                      -padx => 30, -pady => 50,
                      -relief => 'raised',
                      -background => 'DarkSeaGreen2',
                      -activebackground =>'DarkSeaGreen3',
                      -command => \&epidural )
           -> pack(-side =>'bottom', -expand => 1); ##right
##-----------------------------------
# PRINT button
$topwindow  -> Button (-text     => "PRINT LAST CASE",
                      -padx => 60, -pady => 60,
                      -relief => 'raised',
                      -background => 'LightBlue3',
                      -activebackground =>'LightBlue4',
                      -command => \&printout )
                   -> pack(-side =>'right', -expand => 1);
##-----------------------------------
MainLoop;
##-----------------------------------
sub launch {
   if (-e "launchcam12.pl")
     {## first remove the Tk screen
     $topwindow ->destroy if Tk::Exists($topwindow);
     ## $topwindow-> bell; # beeps if click window (p 296)
     system("perl ./launchcam12.pl");
```

```
      system ("perl ./tklaunch2.pl -geometry 300x400-50-300")}
       else{print "....ERROR:\n";
            print "....can't find program <launchcam12.pl>\n\n";exit()}
       }
##-------------------------------
sub quit {exit()}
##-------------------------------
sub printout {
            #$topwindow -> bell;
              $result = $dialog1 -> Show;
             if ($result eq "OK") {};
            }
##-------------------------------
sub projectteam {
            #$topwindow -> bell;
           ##  $result = $dialog2 -> Show;
           ## if ($result eq "OK") {};
           $topwindow ->destroy if Tk::Exists($topwindow);
             ##system ("clear");
             system("xdvi camteama5dvi.dvi -paper a5 -geometry +20+20");
             system ("perl ./tklaunch2.pl -geometry 300x400-50-300");
            }
##-------------------------------
sub epidural {
if (-e "epidural.pl")
      {## first remove the Tk screen
       $topwindow ->destroy if Tk::Exists($topwindow);
       ## now clear the window
       system ("clear");
       ## $topwindow-> bell; # beeps if click window (p 296)
       system("perl ./epidural.pl") ;
       ##system("perl ./tube.pl");
       system ("perl ./tklaunch2.pl -geometry 300x400-50-300")}
       else{print "....ERROR:\n";
            print "....can't find program <epidural.pl>\n\n";exit()}
       }
###--------------$
```

7.4 Useful Linux tools to use with the launcher

In practice it may be easier to use many of the existing Xwindows utilities for displaying manual pages, examples, info and warnings etc. Note that the widget size and screen location can be easily controlled from the commandline using the `-geometry` option.

Chech the relevant options by viewing the manpages for each of these utilities. Note there is a FullScreen option for Tk

```
xclock
xman
xmessage
xdvi  (for viewing .dvi information pages}
xpdf
xghostscript  (for .ps files and ? .pdf)
```

Chapter 8

The launchcam12.pl program

April 19, 2009 /aHOUSE/book-xenon/ch-launchcam.tex/

8.1 Introduction

This perl program is currently used to launch and coordinate the camomile system. It is launched from the perl/Tk widget. Note that currently the program coordinates the printing process by copying a lot of printing utility files into the `/project/pdata/` directory—this will change soon to keep all the printing tools (files) in a separate directory. The program currently performs the following actions.

A Create a time-encoded project directory name `$projdir` for the operation. This is achieved by passing the current `$localtime` to the subroutine `tedname()`. This directory name is also passed to the camomile program as a command-line option (to force camomile to create this particular base directory name for the operation). We add the forward slash to the end of the directory name in order to allow the camomile program to create the `fields` subdirectory (for its output of `.binlog` data files).

```
$timenowgmt = localtime;
$projdir=tedname($timenowgmt);
$projdir=$projdir."/";
```

B Call the camomile program using command-line switches for automatic startup (`-A 1`), Path (`-P`), and configuration file (`-c`) respectively, as follows (need to make sure that everything is all on one line). Note that we also pass the string `$projdir` to the camomile startup command and make camomile itself create the new project directory. Camomile then places all its output data files into the directory `/$projdir/fields/`

```
..../camomile -A 1  -P $projdir  -c ../conf2/c_as3rn.conf
```

C Now write the start-time (in unixtime and localgmttime formats) to a new specially created file `<starttime.dat>`, which we write to a new data directory `/projdir/pdata/`, and is used to facilitate data processing and printing.

Note that we have to wait until Camomile terminates since the starttime and project directoryname are determined *immediately* before starting Cammomile (see A). The time written to the <starttime.dat> file then indicates the “zero” time reference for all subsequent data processing and graphs.

```
open (outfile1, ">$destinationfilename1")
               ||die "ERROR: can’t create file <starttime.dat>\n";
print (outfile1 "%% file name: startfile.dat:  created $timenowgmt\n");
print (outfile1 "%% file generated by <launchcam.pl> RWD Nickalls\n");
print (outfile1 "%% file read by <plotgnnk2.pl> \n");
print (outfile1 "projectdir,$projdir\n");##use commas no spaces
print (outfile1 "starttime,$timenowunix,$timenowgmt\n");##no spaces
close (outfile1);
```

D We now copy all the print-tools utility files to the /project/pdata/ directory in preparation for data processing and printing.

```
system ("cp -v ./printfiles/*.*  $projpdatadir");
```

E We now process all the output files from camomile by calling the utility program plotgnnk.pl.

```
chdir $projpdatadir;
system ("perl ./plotgnnk2.pl");
```

F we now print out all the .dvi files in reverse order by calling the utility printall.pl. (these constitute the printed Anaesthesia Record).

```
if (-e "printall.pl")
   {print "... sending data to the printer now.....\n";
   system ("perl printall.pl");
   print "... done\n\n"}
   else
   {print "ERROR...can’t find program <printall.pl>\n"}
   }
  else
 {print " returning to original dir now.....\n\n"};
```

G Finally, we return to the original directory

```
$returndir="/home/dick/allfiles/camomiletop/datexsim";
chdir $returndir;
print "\n************************\n\n\n\n";
print "     FINISHED\n";
print "\n\n\n************************\n\n";
```

8.2 The program `launchcam12.pl`

```
#! /usr/bin/perl
## launchcam12.pl
## CALLed by the Tk frontend widget (tklaunch2.pl)
##
## April 10, 2004
## for launching camomile and the printing program
##
## RWD Nickalls
## works well -
##=====================
## 1. new version to use Simon's new camomilefields2tex version
##==========================================

##--------------------
## ?? write code to first check that all supporting programs are present
##----------------------
print "===========launchcam12.pl=====\n";

print "... making a time encoded base directory \n";
# grab the starttime
$timenowgmt = localtime;
$timenowunix=time();
## now create the projdir as a timerelated filename
## call the SUB tedname to generate the projdirname
## format of tedname = /home/dick/allfiles/camomiletop/theatredata/$date
## we pass the timenowGMT value to the tedname{} sub
print "calling [sub tedname] for time-encoded dirname\n";
$projdir=tedname($timenowgmt);
## remember to add the / at the end of the dir (so Camomile makes the /fields dir
## as a subdirectory
$projdir=$projdir."/";
print " ... time-encoded directory made OK (=$projdir)\n";
##------------------

print "unixtime= $timenowunix, gmt= $timenowgmt\n";
print "projdir name (tedname) = $projdir\n";

#######====== for testing=======================
####### use this for testing with the dir cam1404fields
####### for 1240 test----
########starttimeunix,1075984828,Thu Feb  5 12:40:28 2004
#$projdir="/home/dick/allfiles/camomiletop/theatredata/cam1240";
#$timenowunix =1075984828;
#$timenowgmt="Thu Feb  5 12:40:28 2004";

##===========camomile starts here=============
print "\n ——————————————\n ...... start of camomile program\n";
##
## run camomile here from   /camomiletop/datexsim/
## keep everything on single line
$campath = "../tarballs/camomile-0.1_040411/camomile/camomile";
  system("$campath -A 1  -P $projdir  -c ../conf2/c_as3rn.conf");

##====Camomile has terminated================
##====so we tidy up, process all the data (make new directory etc),
##=== and return control to launch widget

print "\n ——————————————\n ...... end of camomile program\n";

## flush the buffers after Camomile just to be sure
system ("sync");

## return to <launchcam>
print " ...... returning to <launchcam.pl>\n\n";

##  now create and write the <starttime.dat> file
## since the base dir (project dir) for output is created by Camomile
## we have to wait until camomile terminates before sending
## the <starttime> file to the new /projdir/pdata/ dir
## which will contain all the NEW processed data
## (all the original collected data is in the /projdir/fields/ directory)
## <starttime.dat> file only needed for the printing, ie after running Camomile
## write the starttime file to the /projdir/pdata/ dir

## first need to create the new /pdata/ dir
$projpdatadir=$projdir."pdata/";
mkdir $projpdatadir;
##———————————

## now write the starttime.dat file into the /pdata/ directory
print "writing the <starttime.dat> file to pdata dir ....\n";

  $destinationfilename1=$projpdatadir."starttime.dat"; ##
print " <starttime> destinationfilename1  = $destinationfilename1\n";
  open (outfile1, ">$destinationfilename1")||die "ERROR: can't create file <starttime.dat>\n";
  ##
  print (outfile1 "%% file name: startfile.dat:  created $timenowgmt\n");
  print (outfile1 "%% file generated by <launchcam.pl> RWD Nickalls\n");
  print (outfile1 "%% file read by <plotgnnk2.pl>\n");
  print (outfile1 "projectdir,$projdir\n");##use comma separation & no spaces
  print (outfile1 "starttime,$timenowunix,$timenowgmt\n");##no spaces
  close (outfile1);
  ##
print "......< starttime.dat >.... done\n";
##============

## now copy all the <printfiles> tools to the /projdir/pdata/ dir
print "copying files from  /datexsim/printfiles/  to ../project/pdata/  directory\n";
system ("cp -v ./printfiles/*.*  $projpdatadir");
print "...... done\n";

###===============================================
### now start the (optional) printing process

## now  move to the project/pdata/ dir to CALL the print prog <plotgnnk2.pl>
 print " moving dir --> $projpdatadir\n";
 chdir $projpdatadir;
 print "the new dir is: ...\n";
 system ("pwd");

## now start running the printing process by running <plotgnnk.pl>
print "... now calling  <perl ./plotgnnk2.pl> \n";
system ("perl ./plotgnnk2.pl");

##=================
## finally copy the starttime file to the base dir for safekeeping
print "... now copying file <starttime.dat> to /project/ dir \n";
system ("cp -v starttime.dat  ..");

goto jump;
##=========print OPTION===================
   print "\n ---------------\n";
   print " Press P to PRINT results [q to quit]: ";
   $p = <STDIN>, chomp $p; ##imortant here to remove the <CRLF>
   if (lc($p) eq "p")
         {

         ## check program exists
         if (-e "printall.pl")
```

```
            {print "... sending data to the printer now.....\n";
             system ("perl printall.pl");
             print "... done\n\n"}
            else
            {print "ERROR...can't find program <printall.pl>\n"}
        }
    else
        {print " returning to original dir now.....\n\n"};
##======================================================
jump:;

##===============
## now return to the orig dir
print "returning to /datexsim \n";
$returndir="/home/dick/allfiles/camomiletop/datexsim";
chdir $returndir;
print "\n************************\n\n\n\n";
print "      FINISHED\n";
print "\n\n\n************************\n\n";


##===============SUB=================
## note that the <sub> keyword  must be lowercase

sub tedname{
    ## returns a date/time encoded filename--> $projdir;
    ## using the GMT start-time string passed as a parameter
    my $startgmtstring=$_[0];
    my $n= $#_ + 1;
    print " [SUB] starttimestring = $startgmtstring \n";
    print " [SUB] number of args passed = $n\n";
    ## note the main items are <space> separated except hh:mm:ss
    ## format is:     Sun Jan 25 13:24:35 2004
    ## format is:     Sun Jan  5 13:24:35 2004
    ## note get two spaces after the Month if days <10
    # if two spaces in posn 8 and 9 then remove one
    if (substr($startgmtstring,7,2) eq "  ") {substr($startgmtstring,7,2," ")};
    print " [SUB] new translated string = $startgmtstring\n";
    ## now replace spaces with commas
    $startgmtstring =~ tr/ /,/;
    ## make an array
    @stgmt=split (/[,]/, $startgmtstring);
    $day=$stgmt[0];
    $month=$stgmt[1];
    $date=$stgmt[2];
    $hms=$stgmt[3];
    $year=$stgmt[4];
    $noitems=$#stgmt+1;
    print " [SUB] ....orig string = [$startgmtstring]\n";
    print " [SUB] ....extracted gmt part is: $day,$month,$date,$hms,$year\n";
    print " [SUB] ....extracted starttime hh:mm:ss [$hms]\n";
    ## now extract the hh:mm:ss part to get the hh:mm
            @hhmmss=split (/[:]/, $hms);
            $hour=$hhmmss[0];
            $min=$hhmmss[1];
          # $sec=$hhmmss[2];
    #-----------------
    ## force two-digit for date (= day-of-month)
    ## as unix gmt uses only 1 char if less than 10
    if ($date<10){$date="0".$date};
    ## format the datestring as 2004-01-22-1341
    $datestring="$year-$month-$date-$hour$min";
    return "/home/dick/allfiles/camomiletop/theatredata/"."$datestring";
    };
 __END__
```

Part III

The data program—Camomile

Chapter 9

System overview

April 19, 2009 /allfiles/camomile/cam-book/ch-overview.tex/

9.1 Introduction

The Camomile data program was written by Simon Dales (in conjunction with Dick Nickalls) during the period March 2003 to April 2004, and started to be used in the operating theatre during 2004. The program was a sophisticated Linux re-implementation of an earlier MS-DOS prototype developed by Dick Nickalls during the period 1995-2002.

The final version of the code (`camomile.v.0.1_040413b[c-Apr-15-2004]`) worked well, was used uneventfully for approximately 6 months or so (April–September 2006) in the operating theatre at the City Hospital. In fact this code was used during the Carcinoid case of September 28, 2006, described later.

Structure

The anaesthesia work-station accesses data from both the keyboard and the Datex AS/3 anaesthesia monitor. This data is processed and made available to the anaesthetist in various ways; for example, as trend data on the screen, as a printed Anaesthesia Record, as age-corrected MAC, and alarm and warning information. Other aids for the anaesthetist are in the form of 'help' files for decision support, access to an epidural and double-lumen tube database, and timers (e.g. use with diabetic patients as reminders for determining blood sugars and adjustment of insulin/glucose therapy).

The software is 'open source' and designed and written for the Linux operating system. For the purposes of description, the software components fall into the following categories.

- a graphical 'front-end' module for launching the various systems.
- a data collection and display module
- a printing module
- an epidural and double-lumen tube database
- an HTML 'help' module

These are now described briefly in turn.

9.2 Modules

9.2.1 Graphical front-end module

The graphical front-end 'launcher' (`tklaunch2.pl`) is a Perl/Tk program, which is itself launched by typing the command `runcamomile` in a BASH terminal window. Once launched, the Tk widget shows a number of buttons, each of which will launch an application, for example, the Camomile anaesthesia program, an epidural database program, a collection of 'help' files, and an on-line 'user' manual.

9.2.2 Data collection and display module

This is the heart of the Camomile system. It accesses data from the keyboard, mouse and the Datex AS/3 anaesthesia monitor. Raw data is accessed every 5 seconds from the Datex monitor via the serial port, and saved to the hard drive. The data is displayed in trend format (one screen width shows 30 mins of data), and processed in the form of alarms, log entries, and age-corrected MAC.

At the end of the anaesthetic the program is terminated by clicking on the 'exit' option from a pull-down menu, whereupon the graphical front-end is returned.

9.2.3 Printing module

At the end of the anaesthetic all the relevant data (the Anaesthetic Record) is printed out in a form suitable for inclusion in the patient notes. The printing process is initiated by clicking on the relevant button on the graphical front-end.

9.2.4 Epidural database

This is accessed from the fornt-end by clicking on the relevant button. It is a database incorporating epidural and double-lumen tube collected since 1995, and allows the anaesthetist to estimate for a given height and weight of a patient (a) the midline epidural depth and (b) length of the double-lumen tube.

9.2.5 Help files

This is a collection of HTML 'help' files of information useful to the anaesthetist. Much of the information is is the form of City Hospital guidelines, but guidelines from other sources are included.

9.3 Directory structure

The directory structure for Camomile is as follows.

```
/home/.../camomile/
/home/.../camomile/docs/
/home/.../camomiletop/
/home/.../camomiletop/aneshelp/
/home/.../camomiletop/conf2/
/home/.../camomiletop/datexsim/
/home/.../camomiletop/datexsim/printfiles/
```

```
/home/.../camomiletop/tarballs/
/home/.../camomiletop/tarballs/camomile-0.1_040411/
/home/.../camomiletop/tarballs/camomile-0.1_040411/admin/
/home/.../camomiletop/tarballs/camomile-0.1_040411/camomile/
/home/.../camomiletop/tarballs/camomile-0.1_040411/camomile/docs/
/home/.../camomiletop/tarballs/camomile-0.1_040411/camomile/docs/en/
/home/.../camomiletop/tarballs/camomilefield2tex-0.1_040411/camomile/
/home/.../camomiletop/tarballs/camomilefield2tex-0.1_040411/camomile/docs/
/home/.../camomiletop/tarballs/camomilefield2tex-0.1_040411/camomile/docs/en/
/home/.../camomiletop/tarballs/inc/
/home/.../camomiletop/tarballs/inc/port_datex_as3.h
/home/.../camomiletop/theatredata/
/home/.../camomiletop/theatredata/2004-Mar-05-1027/
/usr/local/bin/runcamomile
/usr/local/bin/camomilefield2tex
```

Chapter 10

The Camomile program

April 19, 2009 /aHOUSE/book-xenon/ch-camomile.tex/

10.1 Directory listing of camomile.v.0.1_040413b

This is the directory listing of the final working version of the Camomile program (written by Simon Dales; compiled April 15, 2004).

```
dir listing of camomile.v.0.1_040413b[c-Apr-15-2004]/camomile/
----------------
  1279 Nov 20  2003 bell_off.xpm
  1263 Nov 20  2003 bell_on.xpm
   408 Feb 17  2003 browser_back.xpm
   411 Feb 17  2003 browser_exit.xpm
   409 Feb 17  2003 browser_frwd.xpm
   424 Feb 17  2003 browser_home.xpm
   408 Jun 17  2003 browser_reload.xpm
443496 Apr 13  2004 camomile
 40924 Apr 11  2004 camomile.cpp
  1843 Apr 11  2004 camomiledoc.cpp
  1646 Feb 17  2003 camomiledoc.h
  7422 Dec  8  2003 camomile.h
  1518 Apr 11  2004 camomileview.cpp
  1472 Feb 17  2003 camomileview.h
  1279 Feb 17  2003 camomile.xpm
  4879 Apr 11  2004 dAboutBox.cpp
  1349 Apr 11  2004 dAboutBox.h
 12749 Jun 15  2003 dAboutBox.ui
  3199 Apr 11  2004 dDisplayDial.cpp
   929 Apr 11  2004 dDisplayDial.h
  7631 May 28  2003 dDisplayDial.ui
  1561 Apr 11  2004 dDisplayGraph.cpp
   803 Apr 11  2004 dDisplayGraph.h
  2066 May 29  2003 dDisplayGraph.ui
  1776 Apr 11  2004 dDisplayNow.cpp
   850 Apr 11  2004 dDisplayNow.h
  6610 Apr 11  2004 dDrugs.cpp
  1437 Apr 11  2004 dDrugs.h
 20122 Aug  8  2003 dDrugs.ui
  6507 Apr 11  2004 dDude.cpp
  1342 Apr 11  2004 dDude.h
 18533 Jun 30  2003 dDude.ui
  3631 Apr 11  2004 dHelpBrowser.cpp
  1099 Apr 11  2004 dHelpBrowser.h
  6584 Feb 17  2003 dHelpBrowser.ui
  4096 Apr 13  2004 docs
  6571 Apr 11  2004 dPatient.cpp
  1491 Apr 11  2004 dPatient.h
 16147 Jun 19  2003 dPatient.ui
  7125 Apr 11  2004 dPort_Datex_AS3.cpp
  1566 Apr 11  2004 dPort_Datex_AS3.h
 20554 Apr 11  2004 dPort_Datex_AS3.ui
 13874 Apr 11  2004 dPort_Graseby3400.cpp
  2397 Apr 11  2004 dPort_Graseby3400.h
 44245 Apr 11  2004 dPort_Graseby3400.ui
  4029 Apr 11  2004 dProject.cpp
  1112 Apr 11  2004 dProject.h
  6625 Apr 11  2004 dProjectNew.cpp
  1309 Apr 11  2004 dProjectNew.h
  8467 Jun 19  2003 dProject.ui
  8940 Apr 11  2004 dPumpController.cpp
  1890 Apr 11  2004 dPumpController.h
  6725 Apr 11  2004 dPumpController_Nickalls.cpp
  1615 Apr 11  2004 dPumpController_Nickalls.h
 17823 Aug 22  2003 dPumpController_Nickalls.ui
 24388 Apr 11  2004 dPumpController.ui
  4428 Apr 11  2004 dSplash.cpp
   925 Apr 11  2004 dSplash.h
  7790 Feb 17  2003 dSplash.ui
  1979 Apr 11  2004 dTestABC.
   863 Apr 11  2004 dTestABC.h
  4683 Mar  5  2003 dTestListView.ui
  5074 Apr 11  2004 dTextWindow.cpp
  1346 Apr 11  2004 dTextWindow.h
 14654 Nov 24  2003 dTextWindow.ui
  7969 Apr 11  2004 dTimer.cpp
  1574 Apr 11  2004 dTimer.h
 22117 Jun 19  2003 dTimer.ui
  1273 Mar  5  2003 dude_anaesthetist.xpm
  1283 Mar  5  2003 dude_patient.xpm
  1298 Mar  6  2003 dude_surgeon.xpm
   422 Jul  3  2003 entry_comment.xpm
   450 Feb 17  2003 entrydrug.xpm
   473 Aug  8  2003 entrytimer_diabetes.xpm
   453 Feb 17  2003 entrytimer.xpm
   326 Feb 17  2003 filenew.xpm
   416 Feb 17  2003 fileopen.xpm
   381 Feb 17  2003 filesave.xpm
  1266 Feb 18  2003 helpbrowse.xpm
  2366 Apr 11  2004 main.cpp
  5703 Apr 13  2004 Makefile.am
 69286 Apr 13  2004 Makefile.in
     0 Feb 17  2003 mini-camomile2.xpm
   433 Jul 12  2003 out_blood.xpm
   418 Jul  9  2003 out_urine.xpm
   383 Apr  1  2003 projectclose.xpm
   370 Apr  1  2003 projectnew.xpm
   367 Apr  1  2003 projectopen.xpm
   430 Feb 17  2003 projectoptions.xpm
  1281 Mar  5  2003 start_stop.xpm
  3871 Apr 10  2004 taboutbox.cpp
  1556 Jun 15  2003 taboutbox.h
  1808 Apr 10  2004 tapplication.cpp
  1493 Feb 17  2003 tapplication.h
  7221 Apr 10  2004 tapplicationsetting.cpp
  3237 Apr  5  2004 tapplicationsetting.h
  1723 Aug 20  2003 tcamomilecolor.cpp
  1432 Aug 20  2003 tcamomilecolor.h
  1951 Mar 31  2003 tchecksums.cpp
  1401 Mar 31  2003 tchecksums.h
  3756 Apr 11  2004 tclock.cpp
  2087 Apr 10  2004 tclock.h
  1013 Aug 20  2003 tcolor.h
 10347 Apr 10  2004 tcommandline.cpp
  1199 Feb 17  2003 tcommandline.h
 10954 Apr 13  2004 tdatastore.cpp
  3616 Apr 13  2004 tdatastore.h
  9310 Apr 10  2004 tdictionary.cpp
  3891 Aug 19  2003 tdictionary.h
  1203 Mar 27  2003 tdimensions.h
 25392 Apr 10  2004 tdocscript.cpp
  1259 Mar  6  2003 tdocscript.h
  1144 Aug 12  2003 tempclass.cpp
  1156 Aug 12  2003 tempclass.h
  9156 Apr 13  2004 tentrydrugs.cpp
  2270 Jul 30  2003 tentrydrugs.h
  5913 Apr 13  2004 tentrydude.cpp
  2368 Jun 19  2003 tentrydude.h
  4710 Apr 13  2004 tentrypatient.cpp
  1452 Mar 26  2003 tentrypatient.h
  8588 Apr 10  2004 tentrytimer.cpp
  1668 Jul  3  2003 tentrytimer.h
  6943 Jan 23  2004 tfilesystem.cpp
  2550 Jun 19  2003 tfilesystem.h
  1225 Apr 13  2004 tguisetups.cpp
  1226 Apr 13  2004 tguisetups.h
  6220 Apr 10  2004 thelpbrowser.cpp
  1628 Jun 23  2003 thelpbrowser.h
  4840 Apr 10  2004 ticonfactory.cpp
  1640 Mar  6  2003 ticonfactory.h
  2401 Apr 13  2004 tlogevent_device_event.cpp
  1704 Apr  5  2004 tlogevent_device_event.h
  2592 Nov 21  2003 tlookup_vapour.cpp
  1314 Nov 17  2003 tlookup_vapour.h
  1072 Mar 11  2003 tport.cpp
  1311 Mar 16  2003 tport.h
  7129 Apr 10  2004 tportserial.cpp
  5964 Apr 10  2004 tportserial_datex_as3.cpp
  1810 Dec  3  2003 tportserial_datex_as3.h
  4024 Apr 10  2004 tportserial_graseby_3400.cpp
  1716 Nov  4  2003 tportserial_graseby_3400.h
  2486 Aug 29  2003 tportserial.h
  7358 Apr 10  2004 tproject.cpp
  3066 Apr 10  2004 tprojectdialog.cpp
  1497 Mar  6  2003 tprojectdialog.h
  3242 Apr 10  2004 tproject.h
  1940 Aug 20  2003 tsampler_displaybase.cpp
  1882 Aug 20  2003 tsampler_displaybase.h
  2255 Aug 20  2003 tsampler_display_clock.cpp
  1488 Aug 20  2003 tsampler_display_clock.h
 15716 Apr 10  2004 tsampler_display_dial.cpp
  1833 Dec 15  2003 tsampler_display_dial.h
 20149 Apr 13  2004 tsampler_display_graph.cpp
  2681 Apr 13  2004 tsampler_display_graph.h
  2529 Apr 10  2004 tsampler_display_lcd.cpp
  1506 Aug 20  2003 tsampler_display_lcd.h
  5717 Apr 13  2004 tsampler_display_log.cpp
  1438 Aug 20  2003 tsampler_display_log.h
 17799 Apr 13  2004 tsampler_display_nickallsalarm.cpp
  2130 Nov 24  2003 tsampler_display_nickallsalarm.h
  8086 Apr 11  2004 tsampler_display_nickallsmac.cpp
  1945 Nov 20  2003 tsampler_display_nickallsmac.h
 18135 Apr 10  2004 tsampler_display_nickallsnow.cpp
  1886 Nov 24  2003 tsampler_display_nickallsnow.h
 12174 Apr 11  2004 tsampler_display_pumpcontroller.cpp
  2135 Aug 21  2003 tsampler_display_pumpcontroller.h
  3846 Apr 10  2004 tsampler_display_relaxants.cpp
  1522 Aug 20  2003 tsampler_display_relaxants.h
 28736 Apr 10  2004 tsampler_portbase_datex_as3.cpp
  5505 Dec  1  2003 tsampler_portbase_datex_as3.h
 17744 Apr 10  2004 tsampler_portbase_graseby_3400.cpp
  2417 Aug 28  2003 tsampler_portbase_graseby_3400.h
  4717 Apr 10  2004 tsampler_portbasewidget.cpp
  2355 Apr 10  2004 tsampler_portbasewidget.h
  5643 Apr 10  2004 twaffle.cpp
  2899 Apr 10  2004 twaffle.h
  6805 Apr 10  2004 twidgetfactory.cpp
  1943 Mar 16  2003 twidgetfactory.h
  3348 Apr 11  2004 twidgetfactory_port.cpp
  6181 Apr 10  2004 twidgetfactory_widget.cpp
  1503 Apr 10  2004 twidgetsampler.cpp
  1885 Mar 27  2003 twidgetsampler.h
  2843 Apr 11  2004 widgetTimeEntry.cpp
   889 Apr 11  2004 widgetTimeEntry.h
  6802 Feb 17  2003 widgetTimeEntry.ui
  3865 Apr 11  2004 wRelaxants.cpp
  1155 Apr 11  2004 wRelaxants.h
  8415 Jun 19  2003 wRelaxants.ui
  2558 Apr 11  2004 wRunClock.cpp
   937 Apr 11  2004 wRunClock.h
  5374 Jun 11  2003 wRunClock.ui
  4267 Apr 11  2004 wToolsA.cpp
   781 Apr 11  2004 wToolsA.h
 10811 Feb 17  2003 wToolsA.ui
  5689 Apr 11  2004 wTools.cpp
   926 Apr 11  2004 wTools.h
 16180 Apr  9  2003 wTools.ui
```

Chapter 11

Configuration files

ch-config.tex

11.1 Introduction

All the configuration files are placed in the directory `/camomiletop/conf2/`. At present the hospital program uses only the customised 'RN' configuration files, e.g.`c_as3rn.conf`. The order that the configuration files are input is as follows.

```
c_as3rn.conf
x-configrn.conf ← projectdir.conf
x-widgets.conf
w-monitor-datexas3.conf
x-displays.conf
```

The list of configuration files is as follows.

```
camomile.sty
c_as3.conf
c_as3rn.conf
c_g3400_ro.conf
c_g3400_rw0.conf
projectdir.conf
u-drugs.conf
u-drugsrn.conf
u-people.conf
u-peoplern.conf
u-pumpable.conf
w-display-relaxant.conf
w-monitor-datexas3.conf
w-pumpcontroller-bozo.conf
w-pumpcontroller-nickalls.conf
w-pump-graseby3400.conf
x-config.conf
x-configrn.conf
x-displays.conf
```

```
x-displaysrn.conf
x-set-alarms.conf
x-set-alarmsrn.conf
x-widgets.conf
xx.lst
```

11.2 c_as3rn.conf

```
%&LaTeX
%!camomile
%%OnOff: (beginCamomileConfig,endCamomileConfig)
%%EndCamomileComments
%---------------------------------
\documentclass[a4paper]{article}
\usepackage{geometry}
\geometry{hscale=0.8,vscale=0.85}

%\nofiles

%\voffset=-72bp
%\oddsidemargin=30bp
%\headheight=20bp
%\headsep=5bp

%\textwidth=450bp
%\textheight=770bp
%\oddsidemargin=-10bp

\usepackage{camomile}


\def\docName{Camomile Configuration file @ 11/4/3}

\def\S#1{\section{#1}}
\def\SS#1{\subsection{#1}}
\def\SSS#1{\subsubsection{#1}}

\def\FN#1{{\tt #1}}
\def\fN#1{{\tt #1}}

\def\set#1#2{SET[#1][#2]}

\pagestyle{headings}
\makeindex
\begin{document}

\docName

\tableofcontents
```

```
\S{Introduction}

This is a configuration file for  \Camomile.
It is layed out in \TeX{} so that we can do some form of literate programming.
The alternative could be XML, or look at  \FN{sendmail}'s configuration file.


%\newpage
\S{Configuration}

Notes:

\begin{itemize}
\item screen dimensions in nominal units. On original screen measure off in
whatever units you find convenient (mm, bp etc). When you port this
configuration to another size of monitor, adjust the \fN{pixelsize} parameters.

It is probably best to set your \fN{pixelsize} parameters to an initally
sensible value, say 1000, then adjust from there.

\end{itemize}

\newpage
\beginCamomileConfig
%
\comment{%\newpage
  \SS{Configure Application}
  }
%
\SetCamomileIncludePath{/home/dick/allfiles/camomiletop/conf2/}
\newdict
  %
  \set{path.config}{/home/dick/allfiles/camomiletop/conf2/}%
  \set{class}{main}%
  \newinstance%
   %
\popdict
%
%%%%%\include{x-config.conf}
\include{x-configrn.conf}   %%% Nickalls
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% windows
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\include{x-widgets.conf}
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Ports
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% ::monitors
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%\include{x.monitors.conf}
\include{w-monitor-datexas3.conf}
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% ::Pumps
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%\include{x.pumps.conf}
%\include{xx.bozo_controller.conf}
%\include{xx.nickallscontroller.conf}
%\include{xx.graseby3400.conf}
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% displays
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%\include{x-displaysrn.conf}    %%% Nickalls
\include{x-displays.conf}
%
\endCamomileConfig
\newpage
\S{More Waffle}
\end{document}
%%eof
```

11.3 x_configrn.conf

```
%%%%%%%%%%%%
% config paths
%%%%%%%%%%%%%
\comment{\newpage
  \SS{Configure paths}
  }
\newdict
  %
  \set{path.config}{/home/dick/allfiles/camomiletop/conf2/}%
  \set{path.help.base}{/home/dick/allfiles/camomiletop/docs/help/en/index.html}%
  \set{path.help.cribsheet}{/home/dick/allfiles/camomiletop/aneshelp/index.html}%
  \set{path.help.diabetescrib}{/home/dick/allfiles/camomiletop/aneshelp/diabetes.html}%
  \set{path.project.wd}{/home/dick/allfiles/camomiletop/theatredata}%
%%%%

%%--------------
    %% rwdn  Feb 17 2004 now reads in both paths
%%%\set{path.project.format}{/home/dick/allfiles/camomiletop/theatredata/test/!Y-!M-!D-!h!m}
\include{projectdir.conf}%  %%% has the new dirs from launchcam.pl
 %%-----------
```

```
  \set{title.project.format}{Operation(!Y-!M-!D@!h:!m:!s[!S,!W])}%   %
  \set{app.htmlbrowser}{konqueror \%s}%
  \set{class}{main}%
  \newinstance%
   %
\popdict
%
\comment{\newpage
  \SS{Configure Dialogs}
  }
\newdict
  \set{class}{lists}%
  %\set{subclass}{people}%
  \include{u-peoplern.conf}%
%  %
  \newinstance%
   %
\popdict
%%
\newdict
  \set{class}{lists}%
 %%%%\set{subclass}{drugs}%
  \include{u-drugsrn.conf}%
  %
  \newinstance%
   %
\popdict
%%eof
```

11.4 projectdir.conf

```
%% projectdir.conf:  created Mon Mar  1 19:15:50 2004
%% file generated by <launchcamX.pl> RWD Nickalls
%% this file to be \input{} by /conf2/x-configRN.conf
\set{path.project.format}{/home/dick/allfiles/camomiletop/theatredata/2004-Mar-01-1915/}
%% -------------
```

11.5 w-monitor-datexas3.conf

```
%%
% widgets.conf
% mods:
% 11/4/3: initial
%
%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Ports
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
\comment{%\newpage
  \SSS{Datex AS/3}
  }
%
\newdict
  \set{widget.parent}{widget.monitors}
  \set{class}{port}
  %
  \set{port.parity}{E}
  \set{port.stopbits}{1}
  \set{port.databits}{8}
  \set{port.baud}{19200}
  %\set{reader.rate}{5000} % read at 5s/block
  \set{widget.x}{2}
  \set{widget.y}{2}
  \set{widget.h}{250}
  \pushdict
    %\set{widget.parent}{widget.port.monitor.0}
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% datex port 1
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %
    \set{subclass}{TPort.Datex.AS3.v0.1}
    %
    \set{widget.w}{200}
    %
    \set{sample.period}{5000}%
    \set{device}{/dev/ttyS0}
    %\set{device}{/dev/ttyS1}
    % request start 0 = no, 1 = yes
    %\set{request.start.send}{0}
    % request stop 0 = no, 1 = yes
    %\set{request.stop.send}{0}
    % request stop period 0,-1, whatever
    \set{request.stop.period}{0}
    %
    \set{name}{First Datex}
    \set{logfile}{datex0.dat}
    %
    \set{param.sat.sat}{sat}
    \set{param.inv[0].s}{bp.s}
    \set{param.inv[0].d}{bp.d}
    \set{param.ecg.hr}{ecg.hr}
    \set{param.sat.hr}{sat.hr}
    \set{param.ecg.rr}{ecg.rr}
    \set{param.o2.insp}{o2.insp}
    \set{param.inv[1].m}{cvp}
    %
    \set{param.co2.exp}{co2.exp}
    \set{param.co2.insp}{co2.insp}
    \set{param.co2.rr}{co2.rr}
    \set{param.ecg.rr}{ecg.rr}
    \set{param.fv.tv.insp}{tv.insp}
    \set{param.fv.tv.exp}{tv.exp}
    \set{param.vap.exp}{vap.exp}
    \set{param.vap.insp}{vap.insp}
    \set{param.vap.code}{vap.code}
    \set{param.n2o.exp}{n2o.exp}
    %
    \set{param.nibp.s}{nibp.s}
    \set{param.nibp.d}{nibp.d}
    \set{param.fv.mv.exp}{mv.exp}
  \set{param.fv.pplat}{pplat}
    %
    \set{param.temp[0].t}{temp[0]}
    \set{param.temp[1].t}{temp[1]}
    %
    \newinstance
  \popdict
  %
\popdict
%%eof
```

11.6 People.conf

```
%% people
\add{anaesthetist}{Dick Nickalls}
\add{anaesthetist}{Ken Alagesan}
\add{anaesthetist}{Pam Wade}
\add{anaesthetist}{Ndu Okonkwo}
\add{anaesthetist}{Janet Latter}
%
\add{surgeon}{Ellis Morgan}
\add{surgeon}{David Beggs}
\add{surgeon}{John Duffy}
%
%%eof
```

11.7 Drugs.conf

```
% drugs conf
\add{drugname}{Asprin}
\add{drugname}{Ephedrine}
\add{drugname}{Frusemide}
\add{drugname}{Morphine}
\add{drugname}{Propofol}
\add{drugname}{Remifentanil}
\add{drugname}{Vecuronium}
```

```
......
.....
%%eof
```

11.8 x-widgets.conf

```
%%
% x-widgets.conf
%%%%%%%%%%%%%%%%%%%

\comment{
  %\newpage
  \SSS{Widgets}
  This file should be largely static for a site.
  Draws the window widgets
  }
%
%
%%%%%%%%%%%%%%%%%%%%
%
\newdict
  %
  %x%\set{logfiles}{/projects/apple2/camomile/}%
  %x%\set{app.name}{Camomile Data Display}%
  %
  %\set{display.period}{10001} % update every 10s%
  %\set{display.period}{10000} % update every 10s%
  %\set{display.period}{3000} % update every 10s%
  %\set{display.period}{200} % update every 10s%
  %\set{display.period}{2000} % update every 10s%
  \set{display.period}{1000} % update every 1s%
  %\set{display.period}{100} % update every 100ms%
  %
  \set{pixel.size.x}{3.1234}%
  \set{pixel.size.y}{2.418}%
  \set{pixel.offset.x}{0}%
  \set{pixel.offset.y}{-517}%
  %
  %\set{widget.x}{0}%
  %\set{widget.y}{0}%
  \set{font.size}{10}%
  \set{widget.w}{1015}%
  \set{widget.h}{700}%
  %
  \set{class}{main}%
  \newinstance%
   %
\popdict
```

```
\comment{%\newpage
  \SSS{Windows}
  }
% setup some windows
\newdict
  \set{widget.parent}{main}
  \set{class}{window}
  %
  \pushdict
    %%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% top window
    %%%%%%%%%%%%%%%%%%%%%%%%%%%
    \set{widget.name}{widget.top}
    \set{widget.x}{0}
    \set{widget.y}{0}
    \set{widget.h}{300}
    \set{widget.w}{1015}
    \set{fixed}1
    \newinstance
  \popdict
  %
  \pushdict
    %
    %%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% text window
    %%%%%%%%%%%%%%%%%%%%%%%%%%%
    % setup text window
    \set{widget.name}{widget.text}
    \set{widget.x}{900}
    \set{widget.w}{115}
    %
    \set{widget.y}{300}
    \set{widget.h}{322}
    \newinstance
  \popdict
  %
  %%%%%%%%%%%%%%%%%%%%%%%%%%%
  %% bottom window
  %%%%%%%%%%%%%%%%%%%%%%%%%%%
  \pushdict
    % setup bottom window
    \pushdict
      \set{subclass}{tabbedwindow}
      \set{widget.w}{900}
      %
      \set{widget.y}{280}
      \set{widget.h}{346}
      \set{widget.name}{widget.bottom.big}
      \newinstance
    \popdict
```

```
%
% setup bottom window
\pushdict
  \set{widget.title}{\&Main}
  \set{widget.parent}{widget.bottom.big}
  \set{widget.name}{widget.bottom.frame}
  \newinstance
\popdict
%
\pushdict
  %\set{widget.title}{ZZBottom}
  \set{widget.parent}{widget.bottom.frame}
  \set{subclass}{tabbedwindow}
  %\set{widget.x}{100}
  %\set{widget.w}{650}
  \set{widget.w}{550}
  %
  \set{widget.y}{0}
  \set{widget.h}{322}
  \set{widget.name}{widget.bottom}
  \newinstance
\popdict
%
\pushdict
  % setup bottom tabbed window
  \set{widget.parent}{widget.bottom}
  \pushdict
    \set{widget.parent}{widget.bottom.big}
    %
    \set{widget.title}{\&Gases}
    \set{widget.name}{widget.gases}
    \newinstance
  \popdict
  %
  % setup bottom tabbed window
  \set{widget.title}{\&Alarms}
  \set{widget.name}{widget.alarms}
  \newinstance
  %
  % setup bottom tabbed window
  \set{widget.title}{\&Logs}
  \set{widget.name}{widget.logs}
  \newinstance
  %
  % setup bottom tabbed window
  %\set{widget.title}{Warning \&Robots}
  %\set{widget.name}{widget.warningRobots}
  %\newinstance
  %
  % setup bottom tabbed window
```

```
      %\set{widget.title}{&Calculators}
      %\set{widget.name}{widget.calcs}
      %\newinstance
      %
      % setup bottom tabbed window
      %\pushdict
      %  \set{subclass}{tabbedwindow}
      \set{widget.title}{Monitor\&s}
      \set{widget.name}{widget.monitors}
      \newinstance
      %
      \set{widget.title}{P\&umps}
      \set{widget.name}{widget.pumps}
      \newinstance
      %\popdict
      %
      % setup bottom tabbed window
      \set{widget.title}{\&Other Stuff}
      \set{widget.name}{widget.otherstuff}
      \newinstance
      %
    \popdict
  \popdict
  %
  %
  % more windows here
\popdict
%%eof
```

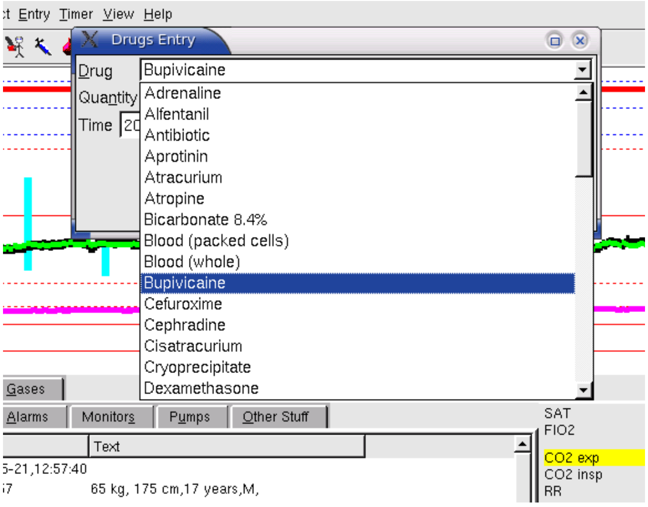
Chapter 12

Drug dictionary

April 19, 2009 /allfiles/camomile/cam-book/ch-drugdict.tex/

12.1 Introduction

The drug dictionary listing used in the pull-down menu of drugs (and IV fluids) was derived from the NHS Dictionary of Medicines and Deviced (DM+D) website (a username and password are required). The listing we used was the Virtual Therapeutic Moiety (VTM) database, and was downloaded every few weeks. This very comprehensive listing is added to periodically by the NHS, and is intended to be ultimately a list of all drugs and associated European-wide numeric codes for use in the NHS. In 2006 this list consisted of approximately 1800 drugs and drug combinations.



Drug Bupivicaine

5-21,12:57:40

65 kg, 175 cm,17 years,M,

Figure 12.1: Screenshot showing the pull-down menu and the drug *Bupivacaine* selected.

12.2 Initial drug list

The drug list uploaded to the workstation was: *u-drugs.conf*, a typical example from June 2003 being as follows.

```
% canomile conf
% drugs01.cfg (15 June, 2003)
\add{drugname}{Adrenaline}
\add{drugname}{Alfentanil}
\add{drugname}{Atracurium}
\add{drugname}{Atropine}
\add{drugname}{Bicarbonate 8.4\%}
\add{drugname}{Blood (packed cells)}
\add{drugname}{Blood (whole)}
\add{drugname}{Cefuroxime}
\add{drugname}{Cisatracurium}
\add{drugname}{Dexamethasone}
\add{drugname}{Dextrose 5\%}
\add{drugname}{Diamorphine}
\add{drugname}{Digoxin}
\add{drugname}{Ephedrine}
\add{drugname}{Erythromycin}
\add{drugname}{Etomidate}
\add{drugname}{Fentanyl}
\add{drugname}{FFP}
\add{drugname}{Frusemide}
\add{drugname}{Gelofusin}
\add{drugname}{Glycopyrollate}
\add{drugname}{GTN}
\add{drugname}{Hartmans solution}
\add{drugname}{Heparin}
\add{drugname}{HESPAN}
\add{drugname}{Hydrocortisone}
\add{drugname}{Isoprenaline}
\add{drugname}{Metariminol}
\add{drugname}{Methoxamine}
\add{drugname}{Metronidazole}
\add{drugname}{Morphine}
\add{drugname}{Noradrenaline}
\add{drugname}{Normal Saline}
\add{drugname}{Phenylephrine}
\add{drugname}{Potassium}
\add{drugname}{Propofol}
\add{drugname}{Protamine}
\add{drugname}{Remifentanil}
\add{drugname}{Rocuronium}
\add{drugname}{Salbutamol}
\add{drugname}{Saline 0.9\%}
\add{drugname}{SNP}
\add{drugname}{Suxamethonium}
```

```
\add{drugname}{Thiopentone}
\add{drugname}{Vancomycin}
\add{drugname}{Vecuronium}
%%eof
```

However, I started writing some Perl programs to extract and process the NHS listing whch could be downloaded from the DM+D website.

12.3 Download bundle

Each download bundle had a filename something like `week192006-r2_3.zip` (ie., the bundle for week 19, 2006), consisting of the following files.

```
amp_v2_3.xsd
amp_v2_3.xsd
BNF
f_amp2_3110506.xml
f_ampp2_3110506.xml
f_ingredient2_3110506.xml
f_lookup2_3110506.xml
f_vmp2_3110506.xml
f_vmpp2_3110506.xml
f_vtm2_3110506.xml
ingredient_v2_3.xsd
letters
lookup_v2_3.xsd
vmpp_v2_3.xsd
vmp_v2_3.xsd
vtm_v2_3.xsd
```

12.4 VTM File format

The `f_vtmXXX.xml` database (114 KB in this particular case) is an XML formatted database of about 1800 drugs and drug combinations (week 19, 2006).

```
<?xml version="1.0" encoding="utf-8" ?>
<VIRTUAL_THERAPEUTIC_MOIETIES xsi:noNamespaceSchemaLocation="vtm_v2_2.xsd"
xmlns="" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"  >
<!-- Generated by Prescription Pricing Authority -->
<VTM><VTMID>68088000</VTMID><NM>Acebutolol</NM></VTM>
<VTM><VTMID>90332006</VTMID><NM>Paracetamol</NM></VTM>
<VTM><VTMID>33664007</VTMID><NM>Acetazolamide</NM></VTM>
<VTM><VTMID>108974006</VTMID><NM>Abciximab</NM></VTM>
<VTM><VTMID>109077006</VTMID><NM>Acarbose</NM></VTM>
<VTM><VTMID>398910009</VTMID><NM>Acebutolol + Hydrochlorothiazide</NM></VTM>
<VTM><VTMID>329923004</VTMID><NM>Aceclofenac</NM></VTM>
<VTM><VTMID>116084008</VTMID><NM>Abacavir</NM></VTM>
....
....
```

```
<VTM><VTMID>9835811000001101</VTMID><NM>Medium-chain triglycerides + Soyaoil</NM></VTM>
<VTM><VTMID>9835911000001106</VTMID><NM>Dornase alfa</NM></VTM>
<VTM><VTMID>9836011000001103</VTMID><NM>Drotrecogin alfa</NM></VTM>
<VTM><VTMID>9837611000001107</VTMID><NM>Homeopathic cocculus indicus</NM></VTM>
</VIRTUAL_THERAPEUTIC_MOIETIES>
```

12.5 Perl program dn-dmd5.pl

```
#!/usr/bin/perl

# dn-dmd5.pl  (modified from dn-dmd4.pl)
# to accommodate the <INVALID> tag
# RWDN   May 14, 2006
## to read the xml  VTM files to extract the drug names and codes
##---------------------------------------
# <VIRTUAL_THERAPEUTIC_MOIETIES>   file=f-vtm2....xml week50-2005
#="vtm_v2_2.xsd"
##-------------------------------------
## TO DO
## search the vtm.XSD file  for all the  key TAGS,
##   and then extract  these from the VTM.xml file
## search for the other possible key words
## search for the <INVALID> ... </INVALID>  **done
## search for the <ABBREVNM> ... </ABBREVNM>
##
## set up commandline flags --in etc
## so user can specify input and output filenames etc
##---------------------------
use strict;
use warnings;
use Carp;  # allows croak "" and warn "" (warn always -> to STDERR)
use Fatal qw(open close);  # for errors
##use Perl6::Builtins qw( system );
#use Getopt::Long;  ## for commandline stuff
#use version;

##========================
# create a printer-log file
  open  my $logg, ">", "dn-dmdlog.log"||die "ERROR: can't open dn-dmdlog.log  file\n";
## grab current time
my $time_now_unix=time(); ## seconds
my $time_now_string=localtime($time_now_unix);
  print {$logg} "rnalarm.log,  ",$time_now_string,": Unix=",$time_now_unix,"\n";
  print {$logg} "log of my Perl rnalarm3.pl  program \n";
#==================================================


#----------------set up the in and out files ------------------
#open my $infile, "<", "test-vtm23.txt" || die "ERROR: can't open INfile   \n";
###open my $infile, "<", "dn-fvtm2xml.txt" || die "ERROR: can't open INfile   \n"; # w50-2005
open my $infile, "<", "vtm23-w19y2006xml.txt" || die "ERROR: can't open INfile week19  \n";
#----
open my $outfile, ">", "test-out-vtm.txt" || die "ERROR: can't open OUTfile   \n";
open my $outfile2, ">", "test-outsorted.txt" || die "ERROR: can't open OUTsortedfile   \n";

##--------------------------------------
## now read each line in the file, and place parameters into an array
    print "...reading the infile file line-by-line\n";
    print {$logg} "...reading the infile file line-by-line\n";

## set the eventFLAG
my $eventnumber=0;   # counts the number of durg/value pairs in the dictionary
my $eventFLAG="OFF";

 # initialise variables
my $uid1 = 0;
my $uid2 = 0;
my $uid = "";
my $begincode="<VTM>";
my $endcode="</VTM>";
my $len = 0;
my $f1=0;
my $m1 = 0;
my $e1=0;
my $invalid=0;
my $invalidflag="OFF";

my $dataline="";
my $newline="";
my $p=" + ";

my $drugcode="";
my $drugname="";

my $delement;
my $REVstring;

# define the Unsorted drugname array
my @udrugname = ();

# define the hash (for drugname/drugcode pairs
my %dmd=();
```

```
 #----------------------
        LINE:
        while (<$infile>){
        next LINE if /^#/;  #skip # comments
        next LINE if /^%/;  #skip % comments
       next LINE if /^$/;  #skip blank lines
        # grab the whole line as a string
        $newline = $_;
        # append the newline string to any remaining dataline fragment
        # when we start a new line
       $dataline=$dataline.$newline;
        chomp($dataline); # removes the line-ending
#------------------
# reset variables to zero
$uid1 = 0;
$uid2 = 0;
$uid = "";
 $f1=0;
 $m1 = 0;
 $e1=0;

#------------------
      #### @value=split (/[ ,]/, $dataline);
      # print $dataline;
      ## replace CR/LF/space/  with visible chars = newbuffer
          #    $dataline=~ s/\r/<CR>/;
          #    $dataline=~ s/\n/<LF>/;
          #    $dataline=~ s/ /<SPACE>/;
          #    print $dataline, "\n";;

  LINEA:
  if ($dataline=~m/<VTM>/) {
                 if ($eventFLAG eq "ON") {print "FLAG is still ON\n"}
                     else {$eventFLAG="ON", print "FLAG=ON\n"};
                         }

  if ($dataline=~m/$endcode/) {
               $eventFLAG="OFF", print "FLAG=OFF\n";
               ## now analyse the event string to find UID and TEXT
               print "NEW endcode found / starting to extract the name/SNOMEDcode pair--\n";

                 ## increment event counter
                 $eventnumber=$eventnumber + 1;
                 $len=length($dataline);
                 print "len dataline = ",$len, "\n";
        #   print "*dataline = ", $dataline,"\n";
```

```
                    print "string number = ", $eventnumber, "\n";
                    ## process the event string to locate begin and end codes
                    ## get the index positions for UID and SEQUENCE
                    $uid1 = index $dataline, '<VTM>';
                    $uid2 = index $dataline, '</VTM>';
                    print "uid1 = ",$uid1, "\n";
                    print "uid2 = ",$uid2, "\n";
                    $uid = substr($dataline, ($uid1), (($uid2+6) -$uid1));
                    ## print this string to outfile
                      print "UID = ", $uid, "\n";

              #-------------------
              # dissect      out the front, middle, end parts of the string $uid.
              $f1 = index $uid, '<VTM><VTMID>';
              $m1 = index $uid, '</VTMID><NM>';
              $e1 = index $uid, '</NM></VTM>';
         #--------
         ## detect the <INVALID> tag
         $invalid = index $uid, '<INVALID>';
         # if find <INVALID> then remove the current string segment and get next line
         if ($invalid > 1){$invalidflag="ON";
                          print "<INVALID> tag found\n";
                          print "invalid FLAG = ON\n";
                          goto REMOVE};
        #--------
              $drugcode=substr($uid, 12, ($m1-12));  #OK
              print "drugcode = <",$drugcode,"> \n";
              $drugname=substr($uid, ($m1 + 12), ($e1-($m1+12))); #OK
              print "drugname = <",$drugname,"> \n";

              #-------------------------
              # print new format to outfile
              ## this is actual Unordered contents of VTM file
              print {$outfile} "<",$eventnumber,"><",$drugname,"><",$drugcode,">\n";

             # collect all the drugname(s) into an Unsorted array (so we can sort it later)
             push ( @udrugname, $drugname);

             # collect name/code pairs into a hash
             %dmd = (%dmd, $drugname, $drugcode);

#======================
# check drugname for + reverse, and add to listing
## $p = <space>+<space> (defined above)
```

```

if ($drugname=~m/[+]/) {
     print "YES the string has a +\n";
     ## make array of  words separated by space [+]
  my  @words=split (/[+]/, $drugname); #
     # clean out/remove leading and trailing white space from each  string
    my @clean_words =();
     foreach $delement (@words) {
        $delement =~ s/^\s+//; #remove leading white space
        $delement =~ s/\s+$//; # trailing space
        push ( @clean_words, $delement);
      }
 my ($w1,$w2,$w3,$w4,$w5,$w6,$w7) = @clean_words;
    my $n=($#clean_words+1);
     print "n= ",$n,"\n";
     print "   string = ",$drugname,"\n";

     if ($n == 2){
         ## reverse the order
         $REVstring = $w2.$p.$w1;
         print "REVstring = ", $REVstring,"\n";
             $drugname= $REVstring;
             push ( @udrugname, $drugname);  # add to the Unsorted drugname array
             %dmd = (%dmd, $drugname, $drugcode); # add new name/code pair to the hash
                          }
    elsif ($n==3){
      ## only need to have each item first once

      $REVstring = $w2.$p.$w1.$p.$w3;
      print "REVstring = ", $REVstring,"\n";
             $drugname= $REVstring;
             push ( @udrugname, $drugname);  # add to the Unsorted drugname array
             %dmd = (%dmd, $drugname, $drugcode); # add new name/code pair to the hash

      $REVstring = $w3.$p.$w1.$p.$w2;
      print "REVstring = ", $REVstring,"\n";
             $drugname= $REVstring;
             push ( @udrugname, $drugname);  # add to the Unsorted drugname array
             %dmd = (%dmd, $drugname, $drugcode); # add new name/code pair to the hash

                    }
    elsif ($n==4){
     ## no strings with 3 +  as yet
         print "first= ",$w1,"\n";
         print "second= ",$w2,"\n";
         print "third= ",$w3,"\n";
         print "4th= ",$w4,"\n";
```

```
                }
     # else {croak "ERROR: string NOT processed as n+ = ",$n,"\n"};
     else {carp "ERROR***: string NOT processed as n+ = ",$n,"\n";
           print "ERROR***: string NOT processed as n+ = ",$n,"\n"};
      }
#else {print "NO the string has no + \n"};


#============


                REMOVE:
                  #----------------
                ## remove last string from the current dataline
                $dataline= substr($dataline, ($uid2+6), (length ($dataline) - length($uid))  );
                  ## print $uid if invalid tag found
                   if ($invalidflag eq "ON"){print "string not processed\n";
                                                    $invalidflag="OFF";
                                                    print "invalid FLAG = OFF\n"};
       #   print "**dataline = ", $dataline,"\n";
       # sleep 1;
                          print "--------\n";
                          #-------now look for  next string pair---------------
                          print "looking for the next event\n";
                          goto LINEA;

                          ## when fall off end of string, then look for next string
                          print "* ERROR looking for new line/string\n";
                          warn "ERROR must have a problem here as should not get here\n";
                          ### must have a problem here as should not get here
                          next LINE;

                     ##------------
                     ## finally dump the event string and start again
                     }; #end of looking for the endcode if

        ## when fall off end of string,while still looking for the endcode then get another line/string
        print "**looking for new line/string (can't find endcode)\n";
        next LINE;

# print "***", $dataline,"\n";
} ## end of the input loop reading the {$INfile}


##------------------------------------------

 print "no more  events found - termating now\n";
print "----------------\n";
# print "event string = ", $event,"\n";

##--------------------------------------------
# now add missing drugs (if they do not already exist on the VTM list)
## make this be input from a file
# collect name/code pairs into a hash
# $snomed_code = $dmd{$dname};
## need to make this a subroutine which reads the names from a local list

##=============== add drugs from the LOCAL file =====================

print {$logg} "....adding drugs from the LOCAL list \n";
print {$logg} "----------------\n";
my $addname="";
my $addnamecode="----";

# open the input file
open my $datafile, "<", "dn-drugs2add.dat"||die "ERROR: can't open drugs2add.dat file\n";

$newline="";
$dataline="";

    LINE2:
    while (<$datafile>){
            next LINE2 if /^#/;  #skip # comments
            next LINE2 if /^%/;  #skip % comments
            next LINE2 if /^$/;  #skip blank lines
            # grab the whole line as a string
            $newline = $_;
            chomp($newline); # removes the line-ending
            ## split up the line if = present
          my @drugs = split (/[=]/, $newline); #
          my @clean_drugs =();
          foreach $delement (@drugs) {
                $delement =~ s/^\s+//; #remove leading white space
                $delement =~ s/\s+$//; # trailing space
                push ( @clean_drugs, $delement);
               }

          my ($drug1, $drug2)= @clean_drugs;
          $addname=ucfirst $drug1;  ## force Uppercase first letter (ucfirst)

          ## if a synonym (drug1) is given for existing drug using = sign ( = drug2) then
          ## grab  the correct snomed code for drug2, and use it with the synonym

          if ( ($#clean_drugs +1) > 1) {
               $drug2= ucfirst $drug2;  ## force first letter to be Ucase
               ## ie at least two drugs in the input line
               print {$logg} "drug1 = {",$drug1,"}  drug2 ={",$drug2,"}  \n";
               ## check we can actually find the snomed code
               if (exists($dmd{$drug2})) {
                   $addnamecode="——".$dmd{$drug2}."——";
                   }
                   else {
                       print {$logg} "** can't find synonym ",$drug2, "\n";
                       $addnamecode="***ERROR***";
                         }
               }

        ## if only single name given, then just add it to list without snomed code
        ## use code <——> so we can see which entries are added by us
        if (exists($dmd{$addname})) {
            print {$logg} "dmd{addname} = ",$dmd{$addname},"\n";
            print {$logg} " ",$addname, " *** is ALREADY on the VTM list\n";
          # print "** = ",$dmd{$addname},"\n";
            # print {$logg} " ",$drugname, " *** is ALREADY on the VTM list\n";
          print " ",$addname, " *** is ALREADY on the VTM list\n";
               }
          else {
               %dmd = (%dmd, $addname, $addnamecode);  # add new drugname/drugcode pair to the hash
               push ( @udrugname , $addname);   # add new drug only to the Unsorted drugname array
               print {$logg} " ",$addname, " has been put on the list just now\n";
               print " ",$addname, " has been put on the list just now\n";
          }
        ## reset the addnamecode to the default
        $addnamecode = "——";
        print {$logg} "————————\n";
```

```
    }

close ($datafile);
##============================


##------------------------------
# now print out the arrays and hashes as a check
# BBook p 74; works OK
my $key;     ## the drug name
my $value;  ## the Snomed code

while (( $key, $value ) = each (%dmd)) {
        print "$key  => $value\n";
      # sleep 1;
          }
##==================================

# now print the Unsorted  name array
my $element;

foreach $element (@udrugname) {
print "$element \n";
#sleep 1;
}

##===================================

# now sort the array alphabetically from the Unsorted list (@udrugname)
my @sdrugname;
@sdrugname = sort {$a cmp $b} @udrugname;

#================================================
# now print the sorted  name array to the files
## s.. means SORTED
## u.. means UNsorted

my $n=0;
my $listnumber="";
my $dname="";
my $snomed_code="";

open my $camfile, ">", "u-drugsrn.conf-new"||die "ERROR: can't open CAMfile  \n";


foreach $dname (@sdrugname) {
    print "$dname \n";
    $n=$n+1;
    $listnumber="0000".$n;
    $listnumber=substr($listnumber,-4);
    $snomed_code = $dmd{$dname};

    #——————————
    # print to a simple file
    print {$outfile2} "<",$listnumber,"><",$dname,"><",$snomed_code,">\n";
    #——————————

    #print sorted order in format for Camomile
    ## \add{drugname}{...}
     print {$camfile} "\\add{drugname}{",$dname,"}\n";
     #print {$camfile} "\\add{drugname}{",$dname," (",$dmd{$dname},")}\n";
    ##sleep 1;
}

##==================$
 close
 __END__
```

12.6 Perl program `reverse.pl`

```
#!/usr/bin/perl -w
## reverse.pl
## RWD Nickalls 2005
## to reverse a string of n names with +

my $instring = "A1A1 A2A2   +   c1c1  c2c2   +   R1R1 R2R2";
my $p=" + ";
# replace / + /  with just +
# $instring =~ s/$p/+/;

# put the words into an array


if ($instring=~m/[+]/) {
     print "YES the string has a +\n";
     ## make array of  words separated by space [+]
  my  @words=split (/[+]/, $instring); #
     # clean out/remove leading and trailing white space from each  string
    my @clean_words =();
     foreach $element (@words) {
         $element =~ s/^\s+//; #remove leading white space
         $element =~ s/\s+$//; # trailing space
         push ( @clean_words, $element);
      }
 my ($w1,$w2,$w3,$w4,$w5,$w6,$w7) = @clean_words;
    my $n=($#clean_words+1);
     print "n= ",$n,"\n";
     print "    string = ",$instring,"\n";

     if ($n == 2){
          print "REVstring = ", $w2.$p.$w1,"\n";
                         }
    elsif ($n==3){
      print "REVstring = ", $w1.$p.$w3.$p.$w2,"\n";
      print "REVstring = ", $w2.$p.$w1.$p.$w3,"\n";
      print "REVstring = ", $w2.$p.$w3.$p.$w1,"\n";
      print "REVstring = ", $w3.$p.$w1.$p.$w2,"\n";
      print "REVstring = ", $w3.$p.$w2.$p.$w1,"\n";
              }
    elsif ($n==4){
         print "first= ",$w1,"\n";
         print "second= ",$w2,"\n";
         print "third= ",$w3,"\n";
         print "4th= ",$w4,"\n";
              }
     else {print "ERROR: string NOT processed as n = ",$n,"\n"};

     }
else {print "NO the string has no + \n"};
```

12.7 Initial data listing

The above program outputs the list in the existing order (as follows) showing that the list is not ordered alphabetically (this just reflects the fact that drugs are added to the list by the NHS simply in the order they are considered etc). The program then orders the list alphabetically to make it easier to find drugs in the pull-down menu (see below).

Where drugs are in combinations, then the program makes a new entry for each of the combined drugs (while including each of the other ones) so each drug combination appears several times, but each time with a different drug first. This naturally swells the drug listing (in this case from about 1842 entries to 2258—see below).

```
<1><Acebutolol><68088000>
<2><Paracetamol><90332006>
<3><Acetazolamide><33664007>
...
...
<30><Alprazolam><111127002>
<31><Alprostadil><109119001>
<32><Insulin glargine><126212009>
<33><Insulin lispro><388454007>
<34><Insulin aspart><388452006>
<35><Metformin><109081006>
<36><Metformin + Rosiglitazone><409120009>
<37><Glipizide><26124005>
<38><Gliclazide><325238000>
<39><Alteplase><27638005>
<40><Alverine><349818006>
<41><Amantadine><51361008>
```

```
<42><Amifostine><108823002>
....
....
<1837><Levoglutamide><10276011000001106>
<1838><Normal immunoglobulin human><10284111000001108>
<1839><Protein C human><391874000>
<1840><Fibrinogen human + Thrombin human><10284211000001102>
<1841><Interferon gamma><10284311000001105>
<1842><Cerium nitrate + Sulfadiazine silver><10303711000001103>
```

12.8 The ordered list

```
<0001><Abacavir><116084008>
<0002><Abacavir + Lamivudine><9726111000001103>
<0003><Abciximab><108974006>
<0004><Acacia><9810011000001108>
<0005><Acacia + Starch + Tragacanth><10043511000001103>
<0006><Acamprosate><9809711000001100>
<0007><Acarbose><109077006>
<0008><Acebutolol><68088000>
<0009><Acebutolol + Hydrochlorothiazide><398910009>
<0010><Aceclofenac><329923004>
<0011><Acemetacin><329906008>
<0012><Acenocoumarol><79356008>
<0013><Acetarsol><9824411000001102>
<0014><Acetazolamide><33664007>
<0015><Acetic acid><326289007>
<0016><Acetic acid + Honey + Squill><10046311000001100>
<0017><Acetic acid + Turpentine oil><10044711000001105>
<0018><Acetone><333511003>
<0019><Acetylated wool alcohols + Liquid paraffin><9888211000001103>
....
....
<2249><Zoledronic acid><134600006>
<2250><Zolmitriptan><108406003>
<2251><Zolpidem><96231005>
<2252><Zonisamide><398762003>
<2253><Zopiclone><321174005>
<2254><Zotepine><321641006>
<2255><Zuclopenthixol><9723611000001100>
<2256><Zuclopenthixol acetate><9723711000001109>
<2257><Zuclopenthixol decanoate><9723811000001101>
<2258><von Willebrand factor + Factor VIII><319925005>
```

12.9 Adding drugs to the list

Since some of the anaesthesia drugs would be missing from the NHS list, then one had to add these. In order to do this conveniently, a file containing the drugs we wanted to add was created, as follows.

```
%% dn-drugs2add.dat
%% input file for the dn-dmd4.pl program
%% Local drugname = official NHS drugname
%%=========================================
Adrenaline
Atracurium
Isoprenaline
Frusemide = Furosemide
Dextrose-saline = Glucose + Sodium chloride
Normal-Saline 0.9% = Sodium chloride
Saline 0.9% = Sodium chloride
Bicarbonate 8.4% = Sodium bicarbonate
Sodium bicarbonate 8.4% = Sodium bicarbonate
HAS4.5 (Human-albumin-solution-4.5%)
HAS20 (Human-albumin-solution-20%)
Hespan (Hydroxy-ethyl-starch)
Gelofusin
Hartmans-solution = Sodium lactate
Blood (packed cells)
Blood (whole)
Magnesium = Magnesium sulphate
Insulin
Potassium = Potassium chloride
Thiopentone = Thiopental
Cryoprecipitate
FFP (Fresh-frozen-plasma)
PPF (Plasma-protein-fraction)
Esmolol
%%eof
```

As time went by, some of these drugs would be added to the NHS list, and so the program indicated in the log file whether any of the drugs were found in the NHS list, and if so, did not add them.

12.10 Perl program add2list.pl

This program added to the NHS list the drugs in the missing list.

```
#!/usr/bin/perl

## add2list.pl

# # RWDN   Jan 13, 2006
##------------------------------
use strict;
use warnings;
use Cwd;    # to get this PATH, eg    $thisdir=cmd;
use Carp;  # allows croak "" and warn "" (warn always -> to STDERR)
use Fatal qw(open close); # for errors
##use Perl6::Builtins qw( system );
#use Getopt::Long;  ## for commandline stuff
#use version;
#================

my @udrugname = ();

my %dmd = ();
my $drugname="";
my $drugcode="";
$drugname="Atropine", $drugcode="——";
     push ( @udrugname, $drugname);
            # collect name/code pairs into a hash
            %dmd = (%dmd, $drugname, $drugcode);

$drugname="Bupivicaine", $drugcode="————";
     push ( @udrugname, $drugname);
            # collect name/code pairs into a hash
            %dmd = (%dmd, $drugname, $drugcode);
#——————————————


## hash %
my @addlist = ( "Drug1 + drug2",  "Atropine",  "Drug2");

## just array @
my $addname="";
my $novalue=0;

foreach $addname (@addlist) {
    print "$addname \n";

    if (exists($dmd{$addname})) {
         print "** = ",$dmd{$addname},"\n";
              # print {$logg} " ",$drugname, " *** is ALREADY on the VTM list\n";
           print " ",$addname, " *** is ALREADY on the VTM list\n";
                }
     else {
         %dmd = (%dmd, $addname, $novalue); # add new drugname/drugcode pair to the hash
         push ( @udrugname , $addname);  # add new drugname only to the Unsorted drugname array
          # print {$logg} " ",$drugname, " has been put on the list just now\n";
         print " ",$addname, " has been put on the list just now\n";
          }
 print "——————————\n";
}
#——————————
```

```
foreach $addname (@udrugname) {
    print "$addname \n";
}
```

12.11 Logfile generated by add2list.pl

```
rnalarm.log,  Sun May 14 22:12:16 2006: Unix=1147641136
log of my Perl rnalarm3.pl  program
...reading the infile file line-by-line
....adding drugs from the LOCAL list
------------
dmd{addname} = 9885311000001102
 Adrenaline *** is ALREADY on the VTM list
------------
dmd{addname} = 9873211000001103
 Atracurium *** is ALREADY on the VTM list
------------
 Isoprenaline has been put on the list just now
------------
drug1 = {Frusemide}  drug2 ={Furosemide}
 Frusemide has been put on the list just now
------------
drug1 = {Dextrose-saline}  drug2 ={Glucose + Sodium chloride}
 Dextrose-saline has been put on the list just now
------------
drug1 = {Normal-Saline 0.9%}  drug2 ={Sodium chloride}
 Normal-Saline 0.9% has been put on the list just now
------------
drug1 = {Saline 0.9%}  drug2 ={Sodium chloride}
 Saline 0.9% has been put on the list just now
------------
drug1 = {Bicarbonate 8.4%}  drug2 ={Sodium bicarbonate}
 Bicarbonate 8.4% has been put on the list just now
------------
drug1 = {Sodium bicarbonate 8.4%}  drug2 ={Sodium bicarbonate}
 Sodium bicarbonate 8.4% has been put on the list just now
------------
 HAS4.5 (Human-albumin-solution-4.5%) has been put on the list just now
------------
 HAS20 (Human-albumin-solution-20%) has been put on the list just now
------------
 Hespan (Hydroxy-ethyl-starch) has been put on the list just now
------------
 Gelofusin has been put on the list just now
------------
drug1 = {Hartmans-solution}  drug2 ={Sodium lactate}
 Hartmans-solution has been put on the list just now
------------
```

```
 Blood (packed cells) has been put on the list just now
------------
 Blood (whole) has been put on the list just now
------------
drug1 = {Magnesium}  drug2 ={Magnesium sulphate}
 Magnesium has been put on the list just now
------------
 Insulin has been put on the list just now
------------
drug1 = {Potassium}  drug2 ={Potassium chloride}
 Potassium has been put on the list just now
------------
drug1 = {Thiopentone}  drug2 ={Thiopental}
 Thiopentone has been put on the list just now
------------
dmd{addname} = 10170311000001108
 Cryoprecipitate *** is ALREADY on the VTM list
------------
 FFP (Fresh-frozen-plasma) has been put on the list just now
------------
 PPF (Plasma-protein-fraction) has been put on the list just now
------------
dmd{addname} = 77856005
 Esmolol *** is ALREADY on the VTM list
------------
```

12.12 Final list for pull-down menu

Finally, the program output a list suitable for the Workstation program, and which was input on startup. In practice we left the list as the complete list, and were intending to make a special anaesthesia subgroup for use with the workstation. Although this was not finished, in practice the pull-down menu was fast enough for us to simply leave the list as it was.

```
\add{drugname}{Abacavir}
\add{drugname}{Abacavir + Lamivudine}
\add{drugname}{Abciximab}
\add{drugname}{Acacia}
\add{drugname}{Acacia + Starch + Tragacanth}
\add{drugname}{Acamprosate}
\add{drugname}{Acarbose}
\add{drugname}{Acebutolol}
\add{drugname}{Acebutolol + Hydrochlorothiazide}
\add{drugname}{Aceclofenac}
\add{drugname}{Acemetacin}
\add{drugname}{Acenocoumarol}
\add{drugname}{Acetarsol}
\add{drugname}{Acetazolamide}
\add{drugname}{Acetic acid}
```

```
...
...
\add{drugname}{Zinc sulphate + Lithium succinate}
\add{drugname}{Zinc undecenoate + Undecenoic acid}
\add{drugname}{Zoledronic acid}
\add{drugname}{Zolmitriptan}
\add{drugname}{Zolpidem}
\add{drugname}{Zonisamide}
\add{drugname}{Zopiclone}
\add{drugname}{Zotepine}
\add{drugname}{Zuclopenthixol}
\add{drugname}{Zuclopenthixol acetate}
\add{drugname}{Zuclopenthixol decanoate}
\add{drugname}{von Willebrand factor + Factor VIII}
```

Chapter 13

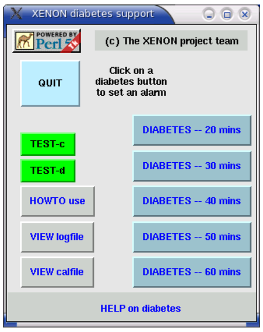
Diabetes decision-support system

RWD Nickalls 2006 April 19, 2009 /aHOUSE/book-xenon/ch-diabetes.tex

13.1 Introduction

The Diabetes decision-support system consists of a diabetes widget which offers information and support as well as an alerting system to remind the anaesthetist to repeat blood sugars etc. This alert system uses the excellent Linux KDE **Kalarm** utility (see below). The **Kalarm** version currently being used with the Xenon workstation (v.0.8.3).

Kalarm is a sophisticated system, and the latest version (1.4.0) is capable of sending emails, displaying text files, triggering an audible voice message, as well as displaying a coloured alert banner following a specified alarm interval, or at a specified date/time. The **Kalarm** system allows input either via a 'form' or via the command-line. The 'form' input method (mouse & keyboard) is, however, rather too complicated and time consuming for use in the theatre environment—input errors would be likely, making the system sufficiently unreliable for anaesthesia use. It was therefore decided to write a Perl-Tk program to generate a widget and info system, which would allow a diabetes alert to be set easily and reliably, simply by clicking on an appropriate widget button.



13.1.1 Kalarm and the iCalendar standard

Kalarm data is written to a text file encoded using the iCalendar Syntax Reference Standard 2445 (RFC 2445), which uses a number of nested so-called V-items, e.g. Valarm, Vevent etc. The following extract is from the Wikipedia entry for *iCalendar* (http://en.wikipedia.org/wiki/ICalendar).

> iCalendar is a standard (RFC 2445 or RFC2445 Syntax Reference) for calendar data exchange. The standard is also known as "iCal", which is the name of the

> Apple Computer calendar program that was the first software implementation of the standard.
>
> iCalendar allows users to send meeting requests and tasks to other users through emails. Recipients of the iCalendar email (with supported software) can respond to the sender easily or counter propose another meeting date/time. It is implemented/supported by a large number of products, including 30Boxes, Google Calendar, Apple iCal application and iPod, Chandler, Lotus Notes, ScheduleWorld, KOrganizer, Lovento, Mozilla Calendar (including Mozilla Sunbird), Mulberry, Novell Evolution, Kronolith, Simple Groupware, Windows Calendar, Nuvvo, Upcoming.org and to some extent, Microsoft Outlook … iCalendar data is typically exchanged using traditional email, but the standard is designed to be independent of the transport protocol. For example, it can also be shared and edited by using a WebDav server. Simple web servers (using just the HTTP protocol) are often used to distribute iCalendar data about an event and to publish busy times of an individual. Event sites on the web are embedding iCalendar data in web pages using hCalendar, a 1:1 representation of iCalendar in semantic XHTML.

13.1.2 VALARM specification from the RFC-2445 manual (v:2, Nov 1998)

```
Internet Calendaring and Scheduling Core Object Specification (iCalendar)
Copyright (C) The Internet Society (1998).  All Rights Reserved.


4.6.6 Alarm Component
   Component Name: VALARM
   Purpose: Provide a grouping of component properties that define an
   alarm.

   Formal Definition: A "VALARM" calendar component is defined by the
   following notation:

          alarmc     = "BEGIN" ":" "VALARM" CRLF
                       (audioprop / dispprop / emailprop / procprop)
                       "END" ":" "VALARM" CRLF

     audioprop  = 2*(

                ; 'action' and 'trigger' are both REQUIRED,
                ; but MUST NOT occur more than once

                action / trigger /

                ; 'duration' and 'repeat' are both optional,
                ; and MUST NOT occur more than once each,
                ; but if one occurs, so MUST the other

                duration / repeat /

                ; the following is optional,
                ; but MUST NOT occur more than once
```

```
           attach /

           ; the following is optional,
           ; and MAY occur more than once

           x-prop

           )



dispprop   = 3*(

           ; the following are all REQUIRED,
           ; but MUST NOT occur more than once

           action / description / trigger /

           ; 'duration' and 'repeat' are both optional,
           ; and MUST NOT occur more than once each,
           ; but if one occurs, so MUST the other

           duration / repeat /

           ; the following is optional,
           ; and MAY occur more than once

           *x-prop

           )



emailprop  = 5*(

           ; the following are all REQUIRED,
           ; but MUST NOT occur more than once

           action / description / trigger / summary

           ; the following is REQUIRED,
           ; and MAY occur more than once

           attendee /

           ; 'duration' and 'repeat' are both optional,
           ; and MUST NOT occur more than once each,
           ; but if one occurs, so MUST the other
```

```
             duration / repeat /

             ; the following are optional,
             ; and MAY occur more than once

             attach / x-prop

             )



  procprop   = 3*(

             ; the following are all REQUIRED,
             ; but MUST NOT occur more than once

             action / attach / trigger /

             ; 'duration' and 'repeat' are both optional,
             ; and MUST NOT occur more than once each,
             ; but if one occurs, so MUST the other

             duration / repeat /

             ; 'description' is optional,
             ; and MUST NOT occur more than once

             description /

             ; the following is optional,
             ; and MAY occur more than once

             x-prop

             )

Description: A "VALARM" calendar component is a grouping of component
properties that is a reminder or alarm for an event or a to-do. For
example, it may be used to define a reminder for a pending event or
an overdue to-do.

The "VALARM" calendar component MUST include the "ACTION" and
"TRIGGER" properties. The "ACTION" property further constrains the
"VALARM" calendar component in the following ways:

When the action is "AUDIO", the alarm can also include one and only
one "ATTACH" property, which MUST point to a sound resource, which is
rendered when the alarm is triggered.

When the action is "DISPLAY", the alarm MUST also include a
```

"DESCRIPTION" property, which contains the text to be displayed when the alarm is triggered.

When the action is "EMAIL", the alarm MUST include a "DESCRIPTION" property, which contains the text to be used as the message body, a "SUMMARY" property, which contains the text to be used as the message subject, and one or more "ATTENDEE" properties, which contain the email address of attendees to receive the message. It can also include one or more "ATTACH" properties, which are intended to be sent as message attachments. When the alarm is triggered, the email message is sent.

When the action is "PROCEDURE", the alarm MUST include one and only one "ATTACH" property, which MUST point to a procedure resource, which is invoked when the alarm is triggered.

The "VALARM" calendar component MUST only appear within either a "VEVENT" or "VTODO" calendar component. "VALARM" calendar components cannot be nested. Multiple mutually independent "VALARM" calendar components can be specified for a single "VEVENT" or "VTODO" calendar component.

The "TRIGGER" property specifies when the alarm will be triggered. The "TRIGGER" property specifies a duration prior to the start of an event or a to-do. The "TRIGGER" edge may be explicitly set to be relative to the "START" or "END" of the event or to-do with the "RELATED" parameter of the "TRIGGER" property. The "TRIGGER" property value type can alternatively be set to an absolute calendar date and time of day value.

In an alarm set to trigger on the "START" of an event or to-do, the "DTSTART" property MUST be present in the associated event or to-do. In an alarm in a "VEVENT" calendar component set to trigger on the "END" of the event, either the "DTEND" property MUST be present, or the "DTSTART" and "DURATION" properties MUST both be present. In an alarm in a "VTODO" calendar component set to trigger on the "END" of the to-do, either the "DUE" property MUST be present, or the "DTSTART" and "DURATION" properties MUST both be present.

The alarm can be defined such that it triggers repeatedly. A definition of an alarm with a repeating trigger MUST include both the "DURATION" and "REPEAT" properties. The "DURATION" property specifies the delay period, after which the alarm will repeat. The "REPEAT" property specifies the number of additional repetitions that the alarm will triggered. This repitition count is in addition to the initial triggering of the alarm. Both of these properties MUST be present in order to specify a repeating alarm. If one of these two properties is absent, then the alarm will not repeat beyond the initial trigger.

The "ACTION" property is used within the "VALARM" calendar component to specify the type of action invoked when the alarm is triggered. The "VALARM" properties provide enough information for a specific action to be invoked. It is typically the responsibility of a "Calendar User Agent" (CUA) to deliver the alarm in the specified fashion. An "ACTION" property value of AUDIO specifies an alarm that causes a sound to be played to alert the user; DISPLAY specifies an alarm that causes a text message to be displayed to the user; EMAIL specifies an alarm that causes an electronic email message to be delivered to one or more email addresses; and PROCEDURE specifies an alarm that causes a procedure to be executed. The "ACTION" property MUST specify one and only one of these values.

In an AUDIO alarm, if the optional "ATTACH" property is included, it MUST specify an audio sound resource. The intention is that the sound will be played as the alarm effect. If an "ATTACH" property is specified that does not refer to a sound resource, or if the specified sound resource cannot be rendered (because its format is unsupported, or because it cannot be retrieved), then the CUA or other entity responsible for playing the sound may choose a fallback action, such as playing a built-in default sound, or playing no sound at all.

In a DISPLAY alarm, the intended alarm effect is for the text value of the "DESCRIPTION" property to be displayed to the user.

In an EMAIL alarm, the intended alarm effect is for an email message to be composed and delivered to all the addresses specified by the "ATTENDEE" properties in the "VALARM" calendar component. The "DESCRIPTION" property of the "VALARM" calendar component MUST be used as the body text of the message, and the "SUMMARY" property MUST be used as the subject text. Any "ATTACH" properties in the "VALARM" calendar component SHOULD be sent as attachments to the message.

In a PROCEDURE alarm, the "ATTACH" property in the "VALARM" calendar component MUST specify a procedure or program that is intended to be invoked as the alarm effect. If the procedure or program is in a format that cannot be rendered, then no procedure alarm will be invoked. If the "DESCRIPTION" property is present, its value specifies the argument string to be passed to the procedure or program. "Calendar User Agents" that receive an iCalendar object with this category of alarm, can disable or allow the "Calendar User" to disable, or otherwise ignore this type of alarm. While a very useful alarm capability, the PROCEDURE type of alarm SHOULD be treated by the "Calendar User Agent" as a potential security risk.

Example: The following example is for a "VALARM" calendar component that specifies an audio alarm that will sound at a precise time and repeat 4 more times at 15 minute intervals:

```
  BEGIN:VALARM
  TRIGGER;VALUE=DATE-TIME:19970317T133000Z
  REPEAT:4
  DURATION:PT15M
  ACTION:AUDIO
  ATTACH;FMTTYPE=audio/basic:ftp://host.com/pub/sounds/bell-01.aud
  END:VALARM
```

The following example is for a "VALARM" calendar component that specifies a display alarm that will trigger 30 minutes before the scheduled start of the event or the due date/time of the to-do it is associated with and will repeat 2 more times at 15 minute intervals:

```
  BEGIN:VALARM
  TRIGGER:-PT30M
  REPEAT:2
  DURATION:PT15M
  ACTION:DISPLAY
  DESCRIPTION:Breakfast meeting with executive\n
   team at 8:30 AM EST.
  END:VALARM
```

The following example is for a "VALARM" calendar component that specifies an email alarm that will trigger 2 days before the scheduled due date/time of a to-do it is associated with. It does not repeat. The email has a subject, body and attachment link.

```
  BEGIN:VALARM
  TRIGGER:-P2D
  ACTION:EMAIL
  ATTENDEE:MAILTO:john_doe@host.com
  SUMMARY:*** REMINDER: SEND AGENDA FOR WEEKLY STAFF MEETING ***
  DESCRIPTION:A draft agenda needs to be sent out to the attendees
    to the weekly managers meeting (MGR-LIST). Attached is a
    pointer the document template for the agenda file.
  ATTACH;FMTTYPE=application/binary:http://host.com/templates/agen
   da.doc
  END:VALARM
```

The following example is for a "VALARM" calendar component that specifies a procedural alarm that will trigger at a precise date/time and will repeat 23 more times at one hour intervals. The alarm will invoke a procedure file.

```
  BEGIN:VALARM
  TRIGGER;VALUE=DATE-TIME:19980101T050000Z
  REPEAT:23
  DURATION:PT1H
  ACTION:PROCEDURE
  ATTACH;FMTTYPE=application/binary:ftp://host.com/novo-
```

```
     procs/felizano.exe
    END:VALARM
```

Before describing the ‘diabetes alert’ widget and the associated Perl programs initiated by clicking on the various buttons, we first give a brief overview of the **Kalarm** system and its command structure, with illustrations linked to the diabetes alarm.

13.2 Kalarm

The Linux **Kalarm** utility is an established and versatile alarm tool which can be developed for use with the anaesthesia workstation. **Kalarm** is maintained by David Jarvie (software@astrojar.org.uk; http://www.astrojar.ork.uk/linux/kalarm.html). The latest version is 1.4.0 (April 2006). **Kalarm** can be accessed either using a ‘form’ via the mouse from the taskbar icon, or via the command-line, and has good documentation via a standard `kalarm --help` command.

Alarms can be both initiated and cancelled using commands issued via the commandline.

13.2.1 To show Kalarm icon

To generate the **Kalarm** icon just type

```
$ kalarm
```

at the command-line, and it will appear on the bottom-bar. The diabetes alarm depends on the **Kalarm** scheduling daemon running; this can be started using the [--reset] option, as follows (see also documentation section below).

```
$ kalarm  --reset
```

13.2.2 Documentation

Online help is available via the command `kalarm  --help-all` as follows. Detailed information is also available from the Kalarm Handbook, which can be accessed via the alarm tray widget (click on ‘help’), and also from /usr/share/doc/HTML/en/kalarm/index.docbook

```
version 0.8.3
Usage: kalarm [Qt-options] [KDE-options] [options] [message]

       kalarm
       kalarm [-bcilLrstu] -f URL
       kalarm [-bcilLrstu] message
       kalarm [-ilLrtu] -e commandline
       kalarm --tray | --reset | --stop
       kalarm --cancelEvent eventID [--calendarURL url]
       kalarm --triggerEvent eventID [--calendarURL url]
       kalarm --handleEvent eventID [--calendarURL url]
       kalarm [generic_options]

KDE personal alarm message and command scheduler
```

```
Generic options:
  --help                    Show help about options
  --help-qt                 Show Qt specific options
  --help-kde                Show KDE specific options
  --help-all                Show all options
  --author                  Show author information
  -v, --version             Show version information
  --license                 Show license information
  --                        End of options

Qt options:
  --display <displayname>   Use the X-server display ’displayname’.
  --session <sessionId>     Restore the application for the given ’sessionId’.
  --cmap                    Causes the application to install a private colour
                            map on an 8-bit display.
  --ncols <count>           Limits the number of colours allocated in the colour
                            cube on an 8-bit display, if the application is
                            using the QApplication::ManyColor colour
                            specification.
  --nograb                  tells Qt to never grab the mouse or the keyboard.
  --dograb                  running under a debugger can cause an implicit
                            -nograb, use -dograb to override.
  --sync                    switches to synchronous mode for debugging.
  --fn, --font <fontname>   defines the application font.
  --bg, --background <color> sets the default background colour and an
                            application palette (light and dark shades are
                            calculated).
  --fg, --foreground <color> sets the default foreground colour.
  --btn, --button <color>   sets the default button colour.
  --name <name>             sets the application name.
  --title <title>           sets the application title (caption).
  --visual TrueColor        forces the application to use a TrueColour visual on
                            an 8-bit display.
  --inputstyle <inputstyle> sets XIM (X Input Method) input style. Possible
                            values are onthespot, overthespot, offthespot and
                            root.
  --im <XIM server>         set XIM server.
  --noxim                   disable XIM.
  --reverse                 mirrors the whole layout of widgets.

KDE options:
  --caption <caption>       Use ’caption’ as name in the titlebar.
  --icon <icon>             Use ’icon’ as the application icon.
  --miniicon <icon>         Use ’icon’ as the icon in the titlebar.
  --config <filename>       Use alternative configuration file.
  --dcopserver <server>     Use the DCOP Server specified by ’server’.
  --nocrashhandler          Disable crash handler, to get core dumps.
  --waitforwm               Waits for a WM_NET compatible windowmanager.
  --style <style>           sets the application GUI style.
  --geometry <geometry>     sets the client geometry of the main widget.
  --nofork                  Don't run in the background.

Options:
  -a, --ack-confirm         Prompt for confirmation when alarm is acknowledged
  -b, --beep                Beep when message is displayed
  -c, --color <color>       Message background colour (name or hex 0xRRGGBB)
  --calendarURL <url>       URL of calendar file
  --cancelEvent <eventID>   Cancel alarm with the specified event ID
  -e, --exec <commandline>  Execute a shell command line
  -f, --file <url>          File to display
  --handleEvent <eventID>   Trigger or cancel alarm with the specified event ID
  -i, --interval <period>   Interval between alarm recurrences
  -l, --late-cancel         Cancel alarm if it cannot be triggered on time
  -L, --login               Repeat alarm at every login
  -r, --repeat <count>      Number of times to repeat alarm (after the initial occasion)
  --reset                   Reset the alarm scheduling daemon
  -s, --sound <url>         Audio file to play
  --stop                    Stop the alarm scheduling daemon
  -t, --time <time>         Trigger alarm at time [[[yyyy-]mm-]dd-]hh:mm, or date yyyy-mm-dd
  --tray                    Display system tray icon
  -u, --until <time>        Repeat until time [[[yyyy-]mm-]dd-]hh:mm, or date yyyy-mm-dd
  --displayEvent <eventID>  Obsolete: use --triggerEvent instead
  --triggerEvent <eventID>  Trigger alarm with the specified event ID

Arguments:
  message                   Message text to display
```

13.2.3 Initiating a diabetes alarm

An example of the command-line (case sensitive) code for initiating a red alarm to prompt the user to repeat a blood-sugar measurement for a diabetic patient, with a pop-up window + beep repeating at 30 mins intervals is as follows (b=beep, c=colour, u=until-hh:mm, i=interval-mmmm).

In Mandrake-Linux the details of the alarm are written to the file /home/dick/.kde/share/apps/kalarm/calendar.ics. The default 'empty' file (ie with no alarms pending) is as follows.

```
BEGIN:VCALENDAR
PRODID:-//K Desktop Environment//NONSGML KAlarm 1.2.10//EN
VERSION:2.0
END:VCALENDAR
```

An example of the command-line (case sensitive) code for initiating a red alarm to prompt the user to repeat a blood-sugar measurement for a diabetic patient, with a pop-up window + beep repeating at 30 mins intervals is as follows (b=beep, c=colour, -t=trigger time yyyy-mm-dd-hh:mm, u=until-hh:mm, i=interval-mmmm).

```
kalarm  -b   -c red  -t 2008-04-10-11:51  -i 0005  -u 2008-04-11-11:31
"DIABETES --- repeat blood sugar"
```

This command generates a new calendar.ics file, which encodes the alarm data. Note that a given alarm instance (VEVENT) may be associated with several alarms (VALARM) in different formats (eg text, displayed file, voice etc) There is one VALARM for the display of message, and another VALARM for the sound of the beep. Note the empty lines following the END: commands.

```
BEGIN:VCALENDAR
PRODID:-//K Desktop Environment//NONSGML KAlarm 1.2.10//EN
VERSION:2.0
   BEGIN:VEVENT
   DTSTAMP:20080410T113102
   ORGANIZER:MAILTO:
   CREATED:20080410T113102
   UID:KAlarm-1412322138.966
   SEQUENCE:-1232236916
   LAST-MODIFIED:20080410T113102
   CLASS:PUBLIC
   PRIORITY:5
   RRULE:FREQ=MINUTELY;UNTIL=20080411T113100;INTERVAL=5
   DTSTART:20080410T115100
   TRANSP:TRANSPARENT
       BEGIN:VALARM
       DESCRIPTION: DIABETES --- repeat blood sugar
       ACTION:DISPLAY
       TRIGGER;VALUE=DURATION:PT0S
       X-KDE-KALARM-FONTCOLOR:#ff0000\;#000000\;
       END:VALARM

       BEGIN:VALARM
       ACTION:AUDIO
       TRIGGER;VALUE=DURATION:PT0S
       END:VALARM

   END:VEVENT

END:VCALENDAR
```

13.2.4 Displaying a file

Note that the "alarm" can be the display of a file. For example, the following code will *immediately* (since no -t option) display a HTML file in a window. Note that there must be NO display "message" argument with this command since in this case the file has taken the place of the message.

```
kalarm -b  -c red  -f "/home/dick/...../file.html"
```

13.2.5 Current alarm status

The list and status of all current outstanding alarms are displayed in the **Kalarm** tray - tabular listing seen by clicking on the **Kalarm** icon on the bottom-bar. The code to place the icon in the bottom-bar tray is as follows.

```
$ kalarm  --tray
```

13.2.6 Cancelling an alarm

The **Kalarm** command (case sensitive) for cancelling an existing alarm having the UID 197659548.1073 as shown above is as follows, which has the effect of deleting the associated VEVENT environment from the calendar.ics file.

```
Kalarm  -cancelEvent  KAlarm-197659548.1073
```

Thus in order to delete an existing alarm 'event' it is necessary to parse the calendar.ics file and determine the UID associated with the particular alarm. Consequently, in order to facilitate identifying the correct UID for an alarm we simply arrange that (a) only a single alarm exists at any one time, and (b) we include a key word, say DIABETES, in the text message.

13.3 Alarm widget program (dn-tkalarm.pl)

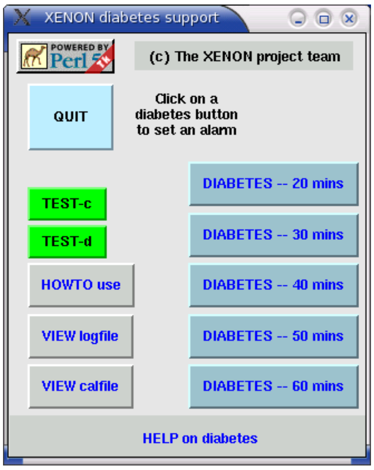


Figure 13.1:
View of the pop-up diabetes support widget. Clicking one of the blue 'diabetes' buttons (20–60 mins) sets an alert for the associated time interval. The three grey buttons are for displaying help information; the two green buttons are for generating test displays.

```
#!/usr/bin/perl
## dn-tkalarm.pl (modified from tklaunch2.pl)
## last modified April 24, 2006

my $thisprog = "[dn-tkalarm.pl]";  #to define this program-name in error messaages

## RWD Nickalls
## last change = Jan 22, 2006
## alarms for Xenon
## Useful books: page 301 Perl core languages (Little Black Book)
##————————————————
## BOOK = Mastering Perl Tk (by: Lidie S and Walsh N (O'Reilly, 2002)
## to get FullScreen mode at startup (p 307)
## -geometry widthXheight+Xoffset+Yoffset (NO spaces**page 409)
## $ perl tklaunch2.pl -geometry 1028x768 -0-0 ## page 409
##  system ("perl ./tklaunch2.pl -geometry 300x400-50-300") }
##————————————————

use warnings;
use strict;
use Carp;
use Fatal;
use Tk;
use Tk::Help;
use Cwd;  # get this path

#————————macros————————
my $beep = "\a"; ##BEEP
my $OS_ERROR =""; ## used in viewcal SUB
my $kalarm_calendar_path="/home/dick/.kde/share/apps/kalarm/calendar.ics";
#——————————————

my $topwindow = MainWindow -> new();
#——————————————————————
$topwindow -> title("XENON diabetes support");
$topwindow -> Label(-text => "Click on a diabetes button to set an alarm",
                    -wraplength =>100,
                    -padx => 0.5,  #250
                    -height => 10 )
             -> pack();

## camel logo
if (-e "./anim.gif"){
my $camelimage = $topwindow -> Photo(-file => './anim.gif');
$topwindow -> Button(-relief => 'flat', -image => $camelimage)
            -> place(-relx=>0.005, -rely=>0);
                    }
#——————————————
# QUIT button
$topwindow  -> Button (-text     => "QUIT",
                       -padx => 20, -pady => 20,
                       -relief => 'raised',
                       -background => 'LightBlue1',
                       -activebackground =>'LightBlue2',
                       -command => \&quit )
```

```
          -> place(-relx=>0.05, -rely=>0.115);
          #-> pack(-side =>'left', -expand => 1);

#-----------------------------
# (c) XENON project team
$topwindow  -> Button (-text    => "(c) The XENON project team",
                   # -padx => 10, -pady => 10,
                    -relief => 'flat',
                    -background => 'LightGrey',
          -activebackground =>'LightGrey',
                    -foreground => 'Black',
         -activeforeground =>'Black',
                    )
                -> place(-relx=>0.35, -rely=>0.016);

#-------------------
# DIABETES 20mins button
$topwindow  -> Button (-text    => "DIABETES -- 20 mins",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                    -background => 'LightBlue3',
                        -activebackground =>'LightBlue2',
      -foreground => 'Blue',
           -activeforeground =>'Red',

                    -command => \&diabetes20 )
                # -> pack(-side =>'right', -expand => 1);
       -> place(-relx=>0.5, -rely=>0.3);
#-----------------
# DIABETES 30mins button
$topwindow  -> Button (-text    => "DIABETES -- 30 mins",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                    -background => 'LightBlue3',
                        -activebackground =>'LightBlue2',
      -foreground => 'Blue',
           -activeforeground =>'Red',

                    -command => \&diabetes30 )
                 # -> pack(-side =>'bottom', -expand => 1);
          -> place(-relx=>0.5, -rely=>0.42);
#----------------
# DIABETES 40mins button
$topwindow  -> Button (-text    => "DIABETES -- 40 mins",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                    -background => 'LightBlue3',
                         -activebackground =>'LightBlue2',
      -foreground => 'Blue',
            -activeforeground =>'Red',

                    -command => \&diabetes40 )
                 # -> pack(-side =>'bottom', -expand => 1);
          -> place(-relx=>0.5, -rely=>0.54);
#------------
# DIABETES 50mins button
$topwindow  -> Button (-text     => "DIABETES -- 50 mins",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                    -background => 'LightBlue3',
                    -activebackground =>'LightBlue2',
      -foreground => 'Blue',
           -activeforeground =>'Red',

                    -command => \&diabetes50 )
                 # -> pack(-side =>'bottom', -expand => 1);
          -> place(-relx=>0.5, -rely=>0.66);
#------------
# DIABETES 60mins button
$topwindow  -> Button (-text     => "DIABETES -- 60 mins",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                    -background => 'LightBlue3',
                         -activebackground =>'LightBlue2',
            -foreground => 'Blue',
                      -activeforeground =>'Red',

                    -command => \&diabetes60 )
                 # -> pack(-side =>'bottom', -expand => 1);
          -> place(-relx=>0.5, -rely=>0.78);
#---------------

#------------
# TEST-COFFEE  demo button
$topwindow  -> Button (-text     => "TEST-c",
                    -padx => 10, -pady => 5,
                    -relief => 'raised',
                    -background => 'Green',
                    -activebackground =>'Yellow',
                     -foreground => 'Black',
           -activeforeground =>'Red',
                    -command => \&testcoffee5 )
                 # -> pack(-side =>'bottom', -expand => 1);
          -> place(-relx=>0.05, -rely=>0.36);

#-------------------------

#------------
# TEST-diabetes  demo button
```

```
$topwindow  -> Button (-text     => "TEST-d",
                    -padx => 10, -pady => 5,
                    -relief => 'raised',
                    -background => 'Green',
                         -activebackground =>'Red',
       -foreground => 'Black',
            -activeforeground =>'Blue',
                    -command => \&testdiabetes )
                 # -> pack(-side =>'bottom', -expand => 1);
           -> place(-relx=>0.05, -rely=>0.45);

#-----------------------------
# HOWTO use  button
 $topwindow  -> Button (-text     => "HOWTO use",
                    -padx => 9, -pady => 10,
                    -relief => 'raised',
                    -background => 'LightGrey',
                         -activebackground =>'Grey',
                     -foreground => 'Blue',
            -activeforeground =>'Red',
                 #   -command => \&errorbox )
   #-command => \&showhelp )
-command => sub{showhelp()})
                 # -> pack(-side =>'bottom', -expand => 1);
           -> place(-relx=>0.05, -rely=>0.54);


#-------------
# VIEW logfile button
$topwindow  -> Button (-text     => "VIEW logfile",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                     -background => 'LightGrey',
                     -activebackground =>'Grey',
                     -foreground => 'Blue',
                      -activeforeground =>'Red',
                    -command => \&viewlog )
                 # -> pack(-side =>'bottom', -expand => 1);
           -> place(-relx=>0.05, -rely=>0.66);

#-------------
# VIEW calendar file button
$topwindow  -> Button (-text     => "VIEW calfile",
                    -padx => 10, -pady => 10,
                    -relief => 'raised',
                     -background => 'LightGrey',
                     -activebackground =>'Grey',
                     -foreground => 'Blue',
                      -activeforeground =>'Red',
                    -command => \&viewcal )
                 # -> pack(-side =>'bottom', -expand =>
                        1);
           -> place(-relx=>0.05, -rely=>0.78);


#-------------------

## HELP button
$topwindow -> Button(-text => "HELP on diabetes",
                        -padx =>115, -pady =>10, -relief =>
                            'flat',
                                  -background =>
                                      'LightGrey',
                          -activebackground =>'Grey',
                                  -foreground => 'Blue',
                          -activeforeground =>'Red',
                                  -command => \&help )
             -> place(-relx=>0, -rely=>0.9);
#---------------------------


 my $diabetes_error_message = "...ERROR running
     dn-alarm-diabetes2 ".$thisprog;

MainLoop;

##===========SUBS========
#-------------
 sub quit {## clear the command-line terminal window and
     then exit
           system ("clear");
           exit();
          }
#-------------------------
sub diabetes20 {
          ##      $topwindow -> bell;
          ##      $result = $dialog1 -> Show;
          ##     if ($result eq "OK") {};
           #    $topwindow ->destroy if
                Tk::Exists($topwindow);
                system ("perl ./dn-alarm-diabetes3.pl -t 20")
                and carp ($diabetes_error_message);
              # system ("perl ./dn-tkalarm.pl -geometry
                  320x380-50-300");
              }
#-------------------
sub diabetes30 {
          ##      $topwindow -> bell;
          ##      $result = $dialog1 -> Show;
          ##     if ($result eq "OK") {};
          #    $topwindow ->destroy if
               Tk::Exists($topwindow);
                system ("perl ./dn-alarm-diabetes3.pl -t 30")
                 and carp ($diabetes_error_message);
              # system ("perl ./dn-tkalarm.pl -geometry
                    320x380-50-300");
                }
#-----------------------
sub diabetes40 {
          ##     $topwindow -> bell;
          ##     $result = $dialog1 -> Show;
          ##    if ($result eq "OK") {};
      #       $topwindow ->destroy if Tk::Exists($topwindow);
                 system ("perl ./dn-alarm-diabetes3.pl -t 40")
                  and carp ($diabetes_error_message);
               # system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
                }
#-----------------------
sub diabetes50 {
          ##     $topwindow -> bell;
          ##     $result = $dialog1 -> Show;
          ##    if ($result eq "OK") {};
      #       $topwindow ->destroy if Tk::Exists($topwindow);
                 system ("perl ./dn-alarm-diabetes3.pl -t 50")
                   and carp ($diabetes_error_message);
               # system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
                }
#-----------------------
sub diabetes60 {
          ##     $topwindow -> bell;
          ##     $result = $dialog1 -> Show;
          ##    if ($result eq "OK") {};
      #       $topwindow ->destroy if Tk::Exists($topwindow);
        system ("perl ./dn-alarm-diabetes3.pl -t 60")
                  and carp ($diabetes_error_message);
               # system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
               } ## end of sub

#-----------------------------
sub testcoffee5 {
        ## test use only 1 min test (-u 1 -i 1)
       ## as this will totally clear after 1 min
                 system ("perl ./dn-alarm-coffee3.pl -u 1");
              #  system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
               }


#-----------------------------
sub testdiabetes {
        ## if use parameters (-u 1) only, then instant and no repeat!
        ## test use only 1 min test (-u 1 -i 1)
      ## as this will totally clear after 1 min

#       system ("perl ./dn-alarm-coffeeRED.pl -u 1");
  system ("perl ./dn-alarm-demoRED.pl");

# system ("kwrite ./anes-files/induction.txt -geometry 350x380-600-300");
           ##  system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
            }

#----------------------------
sub errorbox {
         ## testing area
        ##       $topwindow -> bell;
        ##       $result = $dialog1 -> Show;
        ##      if ($result eq "OK") {};
            $topwindow ->destroy if Tk::Exists($topwindow);
                 print $beep;
          system (qq(perl ./dn-errorbox.pl --in "testing the message box")) ;
      ## now reinstate the Tk diabetes alarm widget
            system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
            }


#--------------------
 sub viewlog {
             $topwindow ->destroy if Tk::Exists($topwindow);
       if (-e "./dnalarm.log")
          {## use my dn-tkviewer.pl utility to view the file
          system ("perl ./dn-tkviewer.pl --in ./dnalarm.log") ;
          system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300")  }
      else{ carp "....ERROR ....can't find file dnalarm.log [dn-tkalarm.pl]";
           system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
               };

    }  ## end of the sub

#--------------------
 sub viewcal {
             $topwindow ->destroy if Tk::Exists($topwindow);
    ##----------
    ## copy latest instance of the file
    ## this is a significant error if the copy fails
    my $thisdir=cwd;
    my $copy_string = "cp  ".$kalarm_calendar_path." ".$thisdir."/dn-calendar.ics";
    system $copy_string
           and carp "could not run $copy_string ($OS_ERROR)" ;
    #Perl-best-practice p 280
    #=====
    ## now view the copied file
    if (-e "./dn-calendar.ics")
        {## use my dn-tkviewer.pl utility to view the file
         system ("perl dn-tkviewer.pl --in ./dn-calendar.ics")
                and carp ("could not run Perl dn-tkviewer.pl ".$thisprog." ($OS_ERROR)") ;
         system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300")  }
      else{print "....ERROR:\n";
           print "....can't find file dn-calendar.ics>\n\n";
           system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
           };
    }  ## end of the sub


#-------------------------------------------------
sub help {
#### this displays the main diabetes help file
             #$topwindow -> bell;
            ##  $result = $dialog2 -> Show;
    $topwindow ->destroy if Tk::Exists($topwindow);
      # if (-e "camteama5dvi.dvi")
    if (-e "../diabetes/diabetes_intro.html")
        {## first remove the Tk screen
        ## $topwindow ->destroy if Tk::Exists($topwindow);
        ## $topwindow-> bell; # beeps if click window (p 296)
          # system("xdvi camteama5dvi.dvi -paper a5 -geometry +20+20");
        #system("konqueror diabetes_intro.html");

  ## if use Simon's Konquered utility, then it needs the FULL path
         system("konquered -geometry 500x550+20+100 /home/dick/allfiles/akalarm/diabetes
         /diabetes_intro.html");
         system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
            }
        else{print "....ERROR:\n";
             print "....can't find program <camteama5dvi.dvi>\n\n";
            system ("perl ./dn-tkalarm.pl -geometry 320x380-50-300");
              };
      } # end of sub
#--------------------------------------


sub showhelp {
   ## opens the small help window
        # create the array of help contents to pass to the help module
        my @helparray = (
    [{-title  => "\n    HOWTO use \n",
                                          -header => "",
                        #  -text    => "This is a description of my application for the help."}],
              -text    => "Click on the headings."}],
#------------------------------
                                             [{-title  => "Overview",
                                               -header => "\nThis widget is an aid for use when anaesthetising a diabetic patient.
          \n\nIt uses the well established Linux KDE Kalarm Open Source alarm utility (www.astrojar.org.uk/linux/\nkalarm.html/).
        \n\nOnce a diabetes alert is set, a red alert window (reminding you to take a blood sugar) will open after the set elapsed time.
      \n\nTest the diabetes alert by first clicking on the green TEST-d button, which will
          generate a demo red alert (simulating the red DIABETES alert). To trigger the TRUE
             diabetes alert system just click on one of the blue DIABETES buttons.
          \n\nIf you are too busy to do a blood-sugar when the red alert window appears, just
          close the window, and the alert will continue to recur at 5-min intervals until
           you set a new alert.",
     -text    => ""}],
#------------------------------
      [{-title  => "Setting an alert",
        -header => "\nSimply click on one of the blue 'DIABETES' buttons. This will automatically set a new alert and delete any previous alert.\n\nThe new alert will appear after the specified time, and then recur every 5-mins
```

```
            until a new blue DIABETES alert is set——or
            until the existing alert is cancelled",
       -text   => ""}],
#——————————————————————————
       [{-title  => "Cancelling an alert",
         -header => "\nClick on the clock icon on the icon
             bar at the bottom of the sceeen (typically on
             the RHS). This will display all the current
             alarms (alerts).\n\nNow select the alarm to be
              cancelled (by right clicking on it), and then
              click on the 'delete' button, and close the
             window.",
         -text   => ""}],

#————————————————————————————————
                                                 [{-title  =>
                                                      "Testing",
                                                   -header =>
                                                        "\nClick on
                                                         the green
                                                        TEST
                                                        butons:\n\nTEST-c\nThis
                                                         is
                                                        generates a
                                                         demo
                                                        COFFEE-break
                                                         reminder
                                                        (yellow).\n\nTEST-d\nThis
                                                         generates
                                                        a RED
                                                        coffee-break
                                                         alert (+
                                                        beep) to
                                                        simulate
                                                        the red
                                                        DIABETES
                                                        alert.",
                                                   -text   =>
                                                        ""}],
#—————————————————————————————
                                                  [{-title  =>
                                                       "Author",
                                                   -header =>
                                                        "\nRWD
                                                        Nickalls\nXenon
                                                         project
                                                        team\nDepartment
                                                         of
                                                        Anaesthesia,\nCity

                                                        Hospital,\nNottingham,\nUK.\n\nemail:

                                                        dicknickalls\@compuserve.com",
                                                   -text   =>
```

```
                                                    ""}],
#——————————————————
                                               [{-title  =>
                                                   "Version/date",
                                                -header =>
                                                    "\nVersion
                                                    1.1 ---
                                                    April 24,
                                                    2006\nFixed
                                                     red
                                                    diabetes
                                                    demo
                                                    alert\n\nVersion

                                                    1.0\nDecember
                                                     18, 2005
                                                    ",
                                                -text    =>
                                                    ""}],
#——————————————————
                                               [{-title  =>
                                                   "DIABETES
                                                   HELP",
                                                -header => "",
                                                -text    =>
                                                    "This is
                                                    only a
                                                    mini-help.\n---for
                                                     a detailed
                                                     help page
                                                    click on
                                                    the 'HELP
                                                    on
                                                    diabetes'
                                                    button at
                                                    the bottom
                                                    of the
                                                    parent
                                                    widget."},
#——————————————————————————
                                               {-title  =>
                                                   "Sliding
                                                   scale",
                                                -header =>
"\n      ITU Sliding Scale\n\n--- Run 5\%Dextrose at 60
    mls/hr\n--- Run insulin actrapid 1Unit/ml  at 0-5
    Units/hr)\n\nGlucose    Insulin rate\nmMol/L
    units/hr\n\n 0 -  3.9      0\n 4 -  6.9      1\n 7 -
    9.9      2\n10 - 14.9      3\n15 - 19.9      4\n      20+
         5",
                                                -text    =>
                                                    ""}]);


```

```
##======
        # create the help object ? needs to go last ?
        my $help = $topwindow->Help(-title       => "XENON diabetes help",
#change parameter values here (see file /Help.pm
    -listfontsize => '14',
    -detailsheaderfontsize =>'14',
    -detailsfontsize => '14',
    -height => '20',              # screen height =50
    -listwidth =>'20',
    -detailswidth => '30',
   # -font =>'Times', # does not work
   # -weight => 'normal', # does not work
#--------------
                                                        -variable =>
                                                            \@helparray);
}
##-------------end-------------------
```

13.4 Test demo programs (`dn-alarm-demoRED.pl`)

There are two test buttons which trigger demo programs; these show a yellow (`dn-alarm-demoYELLOW.pl`) and a red (`dn-alarm-demoRED.pl`) demo alert. The following is the 'red' demo program.

```
#!/usr/bin/perl
## dn-alarm-demoRED.pl

# RWDN Thurs 24April2006
## to look like a diabetes alarm
## main difference is that the trigger option is NOT used here

use warnings;
use strict;
use Carp;  # allows croak ""
use Fatal qw(open close);  # for errors
##use Perl6::Builtins qw( system );
#use version;
#use Cwd;  ##to get this path
##--------------------

my $kalarm_calendar_path="/home/dick/.kde/share/apps/kalarm/calendar.ics";
my $OS_ERROR="";
##========================
# create a printer-log file
  open my $logg, ">", "dnalarm.log"||die "ERROR: can't open dnalarm.log file\n";
  print {$logg} "--- TEST button pressed ---\n";
  print "--- TEST button pressed ---\n";
#=====================================================

## grab current time
my $time_now_unix=time(); ## seconds
my $time_now_string=localtime($time_now_unix);
  print {$logg} "dn-alarm.log,  ",$time_now_string,": Unix=",$time_now_unix,"\n";
  print {$logg} "log of Perl dn-alarm-demoRED.pl program \n";

##-------------------------------
## for NO recurrence
## we need NO trigger time AND ( the -u (until) delay must be LESS than the -i delay)
## so we make -u = (NOWtime + 2mins), and set the -i time to 5mins
my $until_unix= $time_now_unix+ 120; ## = 2mins in secs
my $until_string=localtime($until_unix);
my $until_ymdhm=ymdhm($until_string);
    print "until time = ",$until_ymdhm, " (= +2 mins)\n";
    print "interval time =  5 mins\n";
    print {$logg} "until time = ",$until_ymdhm, " (= +2 mins)\n";
    print {$logg} "interval time =  5 mins\n";
#  format is  $until="-u  2005-12-13-15:36  " (include terminal spaces)
my $until = "-u ".$until_ymdhm."  "; ## the period during which it repeats
##-------------------------------
## set a new alarm
## need -i to be > time to -u
my $message=qq(" time for a COFFEE-break.. Ahh....");
my $out= "kalarm -b  -c red -i 0005 $until $message";
    print "setting new RED COFFEE alarm\n";
    print  "sending Kalarm string = ", $out, "\n";
    print {$logg}  "setting new COFFEE alarm\n";
    print {$logg}  "sending Kalarm string = ", $out, "\n";
system(qq($out))
      and croak "could not run $out ($OS_ERROR)" ;
      #Perl-best-practice p 280

####==============SUBS===================================================
## ymdhm($time-string]);
## need to determine the until time in the correct format for kalarm

  sub ymdhm {
      ## format =  yyyy-mm-dd-hh:hh
      # passing only one time_string into array
      my ($time_string) = @_;
      ##print "---processing parameter [$time_string] \n";

      ## now get the until-time as yyy-mm-dd-hh:mm from the time_string
      ## routine modified from fields2PDATA.pl
          #--------------------------------------------------
    ## note the main items are <space> separated except hh:mm:ss
    ## format is:    Sun Jan 25 13:24:35 2004
    ## format is:    Sun Jan  5 13:24:35 2004
    ## note **** get /two/ spaces after the Month if days <10
    ## see SUB tedname() in launchcam12.pl
    ##--------------------------------------------------
            # if /two/ spaces in posn 8 and 9 then remove /one space/
            if (substr($time_string,7,2) eq "  ") {substr($time_string,7,2," ")};
            ## replace spaces with commas
            $time_string =~ tr/ /,/;
            ## make an array
           my @stgmt=split (/[,]/, $time_string);
            ## $day=$stgmt[0]; ## not used here
           my $month=$stgmt[1];
           my $date=$stgmt[2];
           my $st=$stgmt[3];
           my $year=$stgmt[4];
            ## $noitems=$#stgmt+1;   ## not used here
                   ## now split the time hh:mm:ss --> hh:mm only
          my @sthhmmss=split (/[:]/, $st);
          my $hh=$sthhmmss[0];
          my $mm=$sthhmmss[1];
           ## $ss=$sthhmmss[2]; ## not used here
           # print "the gmt part is: $day,$month,$date,$st,$year\n";
           # print {$logg} "the gmt part is: $day,$month,$date,$st,$year\n";
           ##-----------
           ## but Kalarm requires that both month and date are in numerals
           if ($month eq "Jan"){$month="01"}
           if ($month eq "Feb"){$month="02"}
           if ($month eq "Mar"){$month="03"}
           if ($month eq "Apr"){$month="04"}
           if ($month eq "May"){$month="05"}
           if ($month eq "Jun"){$month="06"}
           if ($month eq "Jul"){$month="07"}
           if ($month eq "Aug"){$month="08"}
           if ($month eq "Sep"){$month="09"}
           if ($month eq "Oct"){$month="10"}
           if ($month eq "Nov"){$month="11"}
           if ($month eq "Dec"){$month="12"}
         my $ymdhm=$year."-".$month."-".$date."-".$hh.":".$mm;
```

```
            return $ymdhm;
        }#end of sub
##————————————————————————————————————
 close
 __END__
##———————————————————end of prog————$
```

13.5 Diabetes alarm program (dn-alarm-diabetes3.pl)

```
#!/usr/bin/perl

# RWDN Thurs 16Dec2005
# d—demo-alarm-diabetes2.pl

use warnings;
use strict;
use Carp;  # allows croak ""
use Fatal qw(open close);  # for errors
##use Perl6::Builtins qw( system );
use Getopt::Long;  ## for commandline stuff
#use version;
use Cwd;  # grab this dir

## DN-alarm-diabetes2.pl (modified from
     dn-alarm-DIABETES1.pl)
## runs Kalarm
##=========initialising==============
my
     $kalarm_calendar_path="/home/dick/.kde/share/apps/kalarm/calendar.ics";
my $OS_ERROR="";
##===================

# create a printer-log file
  open  my $logg, ">", "dnalarm.log"||die "ERROR: can't
       open dnalarm.log file\n";
## grab current time
my $time_now_unix=time(); ## seconds
my $time_now_string=localtime($time_now_unix);
  print {$logg} "dnalarm.log,  ",$time_now_string,":
       Unix=",$time_now_unix,"\n";
  print {$logg} "log of my Perl dnalarm3.pl  program \n";
#================================================

## copy the Kalarm calendar file to this dir with new name
if (-e  $kalarm_calendar_path) {
    print {$logg} "copying the calendar.ics file —>
         dn-calendar.ics \n";
 ## grab the current directtory pathname
  my $thisdir=cwd;
  my $copy_string = "cp  ".$kalarm_calendar_path." ".$thisdir."/dn-calendar.ics";
    system $copy_string
          and croak "could not run $copy_string ($OS_ERROR)" ;
            #Perl-best-practice p 280
         }
   else{ print "ERROR: cannot copy the cal file\n"};
##=======read the calendar file====================

## set the eventFLAG
my $eventnumber=0;  # counter to count the number of DIABETES events
my $eventFLAG="OFF";
open my $calfile , "<", "dn-calendar.ics"||die "ERROR: can't open file  dn-calendar.ics \n";

## now read each line in the file , and place parameters into an array
      print "...reading the CAL file line-by-line\n";
      print {$logg} "...reading the CAL file line-by-line\n";

 # reset these  variables to zero  BEFORE starting the WHILE loop
my $uid1 = 0;
my $uid2 = 0;
my $uid = "";
my $text1 = 0;
my $text2 = 0;
my $text = "";
my $dataline="";
my $event="";

            #-------------------
        LINE: while (<$calfile>){
            next LINE if /^#/;  #skip # comments
            next LINE if /^%/;  #skip % comments
           next LINE if /^$/;  #skip blank lines
            # grab the whole line as a string
            $dataline = $_;
            chomp($dataline); # removes the line-ending
#----------------
# reset variables to zero
$uid1 = 0;
$uid2 = 0;
$uid = "";
$text1 = 0;
$text2 = 0;
$text = "";
#---------------
        #### @value=split (/[,]/, $dataline);
        # print $dataline;
        ## replace CR/LF/space/  with visible chars = newbuffer
            #   $dataline=~ s/\r/<CR>/;
            #   $dataline=~ s/\n/<LF>/;
            #   $dataline=~ s/ /<SPACE>/;
            #   print $dataline, "\n";;
    if ($dataline=~m/BEGIN:VEVENT/) {$eventFLAG="ON", print "FLAG=ON\n";
                                        $event="";
                                        $event=$event.$dataline;
                                       # next LINE;
                                        };
    if ($eventFLAG eq "ON") {$event=$event.$dataline;
                            ## print "event=",$event,"\n";
                            }
    if ($dataline=~m/END:VEVENT/) {
                $eventFLAG="OFF", print "FLAG=OFF\n";
                ## now analyse the event string to find UID and TEXT
          print "NEW event found—checking for word DIABETES\n";
                if ($event=~m/DIABETES/i){
                    ## increment event counter
                    $eventnumber=$eventnumber + 1;
        ##**   $DIABETES_event=$DIABETES_event.$event;

                    # get UID
                    print "DIABETES event found\n";
                    #print "event = ", $event, "\n";
                    ## process the event string to get UID and TEXT
                    ## get the index positions for UID and SEQUENCE
                    $uid1 = index $event, 'UID :KAlarm-';
                    $uid2 = index $event, 'SEQUENCE';
                    print "uid1 = ",$uid1, "\n";
                    print "uid2 = ",$uid2, "\n";
                    $uid = substr($event, ($uid1+5), ($uid2-($uid1+5)));
                    print "UID = ", $uid, "\n";
                    #——
                    ## get the index positions for TEXT and ACTION
                    $text1 = index $event, 'TEXT';
                    $text2 = index $event, 'ACTION';
                    print "text1 = ",$text1, "\n";
                    print "text2 = ",$text2, "\n";
                    $text = substr($event, ($text1+5), ($text2-($text1+5)));
                    print "TEXT = ", $text, "\n";
                    ##———
                    ## cancel the event
                    my $cancel= "kalarm  -cancelEvent ".$uid;
                    print "cancelling existing DIABETES alarm\n";
                    print "sending command: ",$cancel,"\n";
                    print {$logg} "cancelling existing DIABETES alarm\n";
                    print {$logg} "sending command: ",$cancel,"\n";
                    ## if more than one DIABETES event to cancel, then need to
                    ## pause slightly as it takes time for each cancel to take effect
                    if ($eventnumber>1) {sleep 2};
                    system(qq($cancel))
                         and croak "could not run $cancel ($OS_ERROR)" ;
                         #Perl-best-practice p 280


                    ##---------now look at next event-------------

                    print "-------\n";
                    $event="";   ## clear the event string
                    print "looking for the next event\n";
                    next LINE;
                     } # end of if contains word DIABETES conditional
                    else{##print "NEW event found----checking for word DIABETES\n";
                         print "NO DIABETES word in this event, so looking for next event\n";
                      #   print "event = ", $event, "\n";
                         next LINE};
               ##-------------
               ## finally dump the event string and start again
               };

# print "***", $dataline,"\n";
$dataline="";
} ## end of the input loop reading the {$calfile}


##----------------------------------------

 print "no more  events found - termating now\n";
print "--------------\n";
# print "event string = ", $event,"\n";
```

```

##==========================

## get the commandline options (using Getopt::Long)
##   Perl-best-practice p 309
my $trigger_time_mins     = 30; # mins
my $repeat_interval_mins  = 5; # mins
my $until_time_mins       = 1440; # mins = 24hrs
#my $message    = qq("DIABETES:");

my $options_okay = GetOptions(
'trigger=i'   => \$trigger_time_mins,     #--trigger expects an integer mins
'interval=i'  => \$repeat_interval_mins,  # --interval  mins
'until=i'     => \$until_time_mins,       # --until   mins = 1440 =24hrs
#'message=s'  => \$message,               # --message
);

#----------------
## use 2 trailing spaces (to separate items)
my $kalarm="kalarm  ";
my $bell="-b  "; ## -b
my $color="-c red  ";
#$trigger_time_mins=;  ## starttime
#----------------
#$repeat_interval_mins=5; # mins
my $intervala="0000".$repeat_interval_mins;
my $intervalb=substr($intervala,-4);
     print {$logg}  "interval= ", $intervalb,"\n";
my $repeat_interval="-i ".$intervalb."  ";
##----------------
my $message=qq(" DIABETES --- repeat blood sugar ");

    print {$logg} "bell = ", $bell, "\n";
    print {$logg} "color = ", $color, "\n";
    print {$logg} "trigger mins = ", $trigger_time_mins, "\n";
    print {$logg} "interval mins = ", $repeat_interval_mins, "\n";
    print {$logg} "until mins = ", $until_time_mins, "\n";

##------------------------------
## determine the new `trigger' time
## determine final time (= trigger-time)
my $trigger_unix=$time_now_unix+($trigger_time_mins*60); ## secs
## get local time string
my $trigger_string=localtime($trigger_unix);
## get ymdhm of  trigger_time
my $trigger_ymdhm= ymdhm($trigger_string);  ## use the subroutine
#    print "trigger time  hh:mm = ", $trigger_hhmm, "\n";
    print {$logg} "trigger time = ", $trigger_ymdhm, "\n";
```

```
## write the correct trigger string for the Kalarm commandline
my $trigger="-t ".$trigger_ymdhm."  "; ## two trailing spaces
##-------------------------------
## determine the correct until_time  (add 24hrs)
my $until_unix= $time_now_unix+($until_time_mins *60); ## secs
my $until_string=localtime($until_unix);
my $until_ymdhm=ymdhm($until_string);
     #print "until time = ",$until_ymdhm, "\n";
     print {$logg} "until time = ",$until_ymdhm, "\n";
my $until="-u ".$until_ymdhm."  "; ## the period during which it repeats
#  format is  $until="-u  2005-12-13-15:36  ";
##----------------------------------

## testing with file - use the KDE geometry option to get width correct
##$file = "  -f  /home/dick/allfiles/akalarm/perl/help.txt ";
#$out= $kalarm.$color.$until.$repeat_interval.$file;
#-------------------

## set a new DIABETES alarm
#$out= $kalarm.$color.$trigger.$repeat_interval.$until.$message;
my $out= $kalarm.$bell.$color.$trigger.$repeat_interval.$until.$message;
     print "setting new DIABETES alarm\n";
     print  "sending Kalarm string = ", $out, "\n";
     print {$logg}  "setting new DIABETES alarm\n";
     print {$logg}  "sending Kalarm string = ", $out, "\n";
system(qq($out))
       and croak "could not run $out ($OS_ERROR)" ;
       #Perl-best-practice p 280


####===============SUBS==========================================
      ## ymdhm($time-string]);

  sub ymdhm {
       ## format =  yyyy-mm-dd-hh:hh
       # passing only one time_string into array
       my ($time_string) = @_;
       ##print "---processing parameter [$time_string]\n";

      ## now get the until-time as yyy-mm-dd-hh:mm from the time_string
      ## routine modified from fields2PDATA.pl
             #---------------------------------------------------
     ## note the main items are <space> separated except hh:mm:ss
```

```
    ## format is:     Sun Jan 25 13:24:35 2004
    ## format is:     Sun Jan  5 13:24:35 2004
    ## note **** get /two/ spaces after the Month if days <10
    ## see SUB tedname() in launchcam12.pl
    ##-----------------------------------------------------------
             # if /two/ spaces in posn 8 and 9 then remove /one space/
             if (substr($time_string,7,2) eq "  ") {substr($time_string,7,2," ")};
             ## replace spaces with commas
             $time_string =~ tr/ /,/;
             ## make an array
             my @stgmt=split (/[,]/, $time_string);
             ##  $day=$stgmt[0];     ## not used
             my $month=$stgmt[1];
             my $date=$stgmt[2];
             my $st=$stgmt[3];
             my $year=$stgmt[4];
             ## $noitems=$#stgmt+1;    ## not used
                     ## now split the time hh:mm:ss --> hh:mm only
            my @sthhmmss=split (/[:]/, $st);
            my $hh=$sthhmmss[0];
            my $mm=$sthhmmss[1];
            ##     $ss=$sthhmmss[2];    ## not used
            # print "the gmt part is: $day,$month,$date,$st,$year\n";
            # print {$logg} "the gmt part is: $day,$month,$date,$st,$year\n";
            ##-----------
            ## but Kalarm requires that the month and date is in numerals
            if ($month eq "Jan"){$month="01"}
            if ($month eq "Feb"){$month="02"}
            if ($month eq "Mar"){$month="03"}
            if ($month eq "Apr"){$month="04"}
            if ($month eq "May"){$month="05"}
            if ($month eq "Jun"){$month="06"}
            if ($month eq "Jul"){$month="07"}
            if ($month eq "Aug"){$month="08"}
            if ($month eq "Sep"){$month="09"}
            if ($month eq "Oct"){$month="10"}
            if ($month eq "Nov"){$month="11"}
            if ($month eq "Dec"){$month="12"}
            my $ymdhm=$year."-".$month."-".$date."-".$hh.":".$mm;
            return $ymdhm;
      }#end of sub

##===================
 close
 __END__
```

13.6 File viewer program (`dn-tkviewer.pl`)

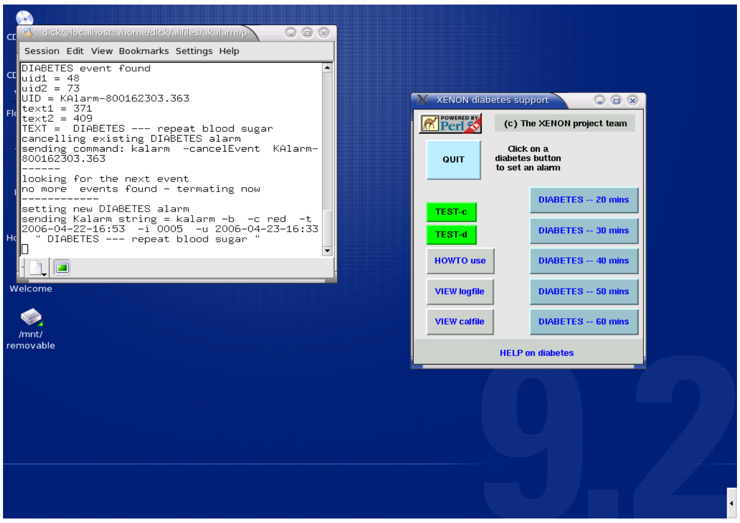
```
#!/usr/bin/perl
## RN-tkviewer.pl (modified from RNtkview.pl)
my $thisprog="[dn-tkviewer.pl]" ;  ## used in error messages
##
## RWD Nickalls
## Dec 16, 2005
## a simple TK fileviewer (takes filename as argument)
##
#----------now make the widget--------------
     ##
     ## BOOK = Mastering Perl Tk (by: Lidie S and Walsh N (O'Reilly, 2002)
     ## to get FullScreen mode at startup (p 307)
     ##  -geometry widthXheight+Xoffset+Yoffset (NO spaces**page 409)
     ## $ perl tklaunch2.pl -geometry 1028x768 -0-0 ## page 409
     ##  system ("perl ./tklaunch2.pl -geometry 300x400-50-300") }
     ## see p 233 PerlTK book
     ## see TEXT widget p 162
     ##
##-----------------------------
use warnings;
use strict;
use Tk;
use Carp;
use Fatal;  ## to give good failure error messages
use Getopt::Long;   ## for command-line (see  my prog ...diabetes2.pl)
#-----------------------------
## get the commandline options ( using Getopt::Long)
##   Perl-best-practice p 309
## to allow an Input filename to view
my $input_filename     = '-';
my $options_okay = GetOptions(
     'in=s'       => \$input_filename, #  --in option expects a string
   );
## usage =  $ perl dn-tkviewer.pl --in filename
##
if ($input_filename eq '-'){croak "...ERROR -- filename not specified ".$thisprog};
##
## define an error message for use later
my $errormessage="...ERROR -- can't find filename <".$input_filename."> ".$thisprog;
## note that this errror messahe must be outside the if(){} statement
##
```

```
if (-e   $input_filename){
      #----------now make the widget--------------
      my $topwindow= MainWindow -> new();
      $topwindow -> title("XENON  file: ".$input_filename);
      my $text = $topwindow->Scrolled("Text",
                  # -background => 'LightGrey',
                  # default background colour is a very pale grey
                   -font => ['courier', '14'],
                                  )
                     ->pack();
      open my $VIEWFILE, "<", $input_filename|| croak $errormessage, " [code A]" ;
      while (<$VIEWFILE>){$text->insert('end',$_)};
      MainLoop;
      close($VIEWFILE);
      }
      else{croak  $errormessage, " [code B]"};
##---------end--------------
```

13.7 Error message widget program (dn-errorbox.pl)

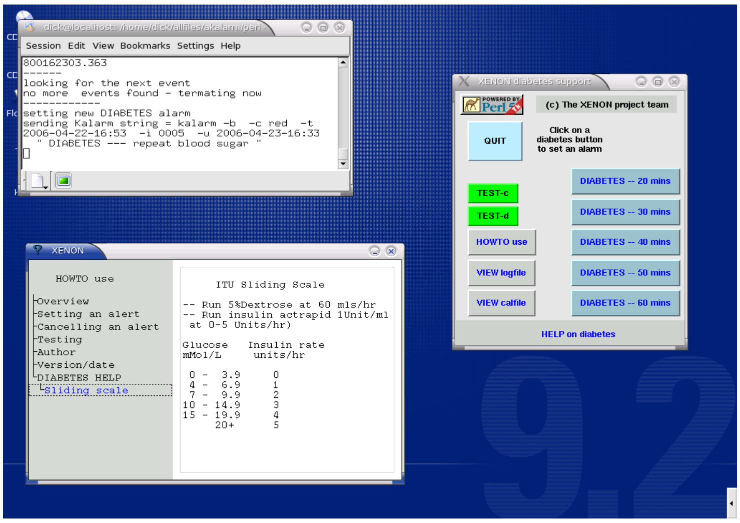
```
#!/usr/bin/perl -w
## RN-errorbox.pl (modified from rntkalarm.pl)
my $thisprog = "[rn-errorbox.pl]";  #to define this program-name in error messaages

##------------------------
## RWD Nickalls
## April 26, 2006.
## message boxes for Xenon
## Useful books: page 301 Perl core languages (Little Black Book)
##-------------------------
## usage:   $ perl dn-errorbox.pl -in "error message is...."
## requires use of the explicit --in tag
##-----------------------
## BOOK = Mastering Perl Tk (by: Lidie S and Walsh N (O'Reilly, 2002)
## to get FullScreen mode at startup (p 307)
##  -geometry widthXheight+Xoffset+Yoffset (NO spaces**page 409)
## $ perl tklaunch2.pl -geometry 1028x768 -0-0 ## page 409
##  system ("perl ./tklaunch2.pl -geometry 300x400-50-300") }
##-------------------------

use Tk;
use Carp;
use Fatal;
use Getopt::Long;   ## gets options from command-line (see my prog ...diabetes2.pl)

#--------------------------
## get the commandline options ( using Getopt::Long)
##   Perl-best-practice p 309
## to allow an Input filename to view
my $message      = '-';
my $options_okay = GetOptions(
'in=s'        => \$message, #  --in option expects a string
);
## usage =  $ perl rn-tkviewer.pl --in filename
##
if ($message eq '-'){croak "...ERROR -- message not specified ".$thisprog," $!"};
##
#-------------------------------------------------
## write the word ERROR underlined
my $error="ERROR MESSAGE\n-----------------------------------------\n\n\n";
my $boxmessage = $error.$message;
##
#--------------------------
$topwindow = MainWindow -> new();
$topwindow -> title("XENON");
$topwindow -> Label(-text => $boxmessage,
                    -wraplength =>200,
                    -padx => 10,
    -background => 'Yellow',
                    -foreground => 'Black',
                    -height => 10,
                    -width => 35 )
         -> place(-anchor => 'n')
                          -> pack();
                   #   ->pack(-side => 'top'); #,-expand =>1);
MainLoop;
##-------------end----------$
```

13.8 Screenshots



```
DIABETES event found
uid1 = 48
uid2 = 73
UID = KAlarm-800162303.363
text1 = 371
text2 = 409
TEXT =  DIABETES --- repeat blood sugar
cancelling existing DIABETES alarm
sending command: kalarm  -cancelEvent  KAlarm-
800162303.363
-------
looking for the next event
no more  events found - termating now
-------------
setting new DIABETES alarm
sending Kalarm string = kalarm -b  -c red  -t
2006-04-22-16:53  -i 0005  -u 2006-04-23-16:33
  " DIABETES --- repeat blood sugar "
```

Figure 13.2:
Screen showing the diabetes alarm widget (right) and the Linux command-line window (left). The widget displays 5 blue time-option buttons (20–60 minutes) which initiate the red interval alarm as shown in the following figure.

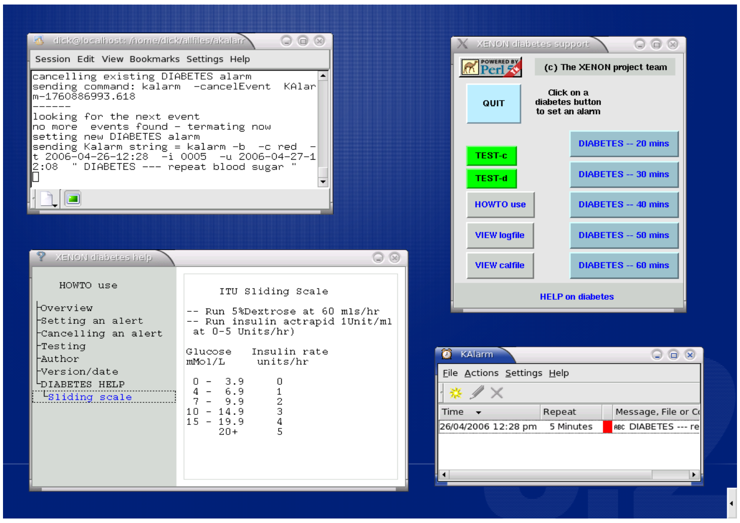


```
800162303.363
-------
looking for the next event
no more  events found - termating now
-------------
setting new DIABETES alarm
sending Kalarm string = kalarm -b  -c red  -t
2006-04-22-16:53  -i 0005  -u 2006-04-23-16:33
  " DIABETES --- repeat blood sugar "
```

```
   HOWTO use

├Overview
├Setting an alert
├Cancelling an alert
├Testing
├Author
├Version/date
└DIABETES HELP
  └Sliding scale
```

```
       ITU Sliding Scale

-- Run 5%Dextrose at 60 mls/hr
-- Run insulin actrapid 1Unit/ml
 at 0-5 Units/hr)

Glucose    Insulin rate
mMol/L      units/hr

 0 -   3.9      0
 4 -   6.9      1
 7 -   9.9      2
10 -  14.9      3
15 -  19.9      4
      20+       5
```

Figure 13.3:
Screen showing the alarm help-window (bottom left) which opens by clicking on the ‘HOWto use’ button. The help-window doubles as a diabetes management information as well as a help feature for using the alarm widget itself.



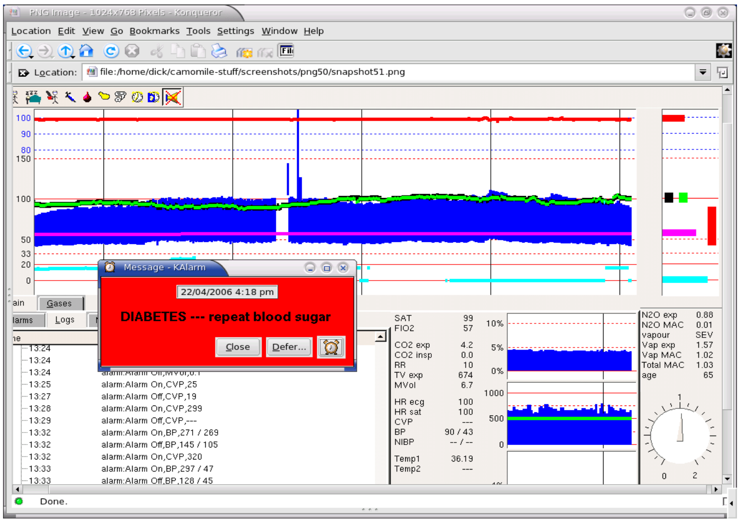
```
cancelling existing DIABETES alarm
sending command: kalarm  -cancelEvent  KAlar
m-1760886993.618
------
looking for the next event
no more  events found - termating now
setting new DIABETES alarm
sending Kalarm string = kalarm -b  -c red  -
t 2006-04-26-12:28  -i 0005  -u 2006-04-27-1
2:08  " DIABETES --- repeat blood sugar "
```

```
    HOWTO use

├Overview
├Setting an alert
├Cancelling an alert
├Testing
├Author
├Version/date
└DIABETES HELP
  └Sliding scale
```

```
     ITU Sliding Scale

-- Run 5%Dextrose at 60 mls/hr
-- Run insulin actrapid 1Unit/ml
 at 0-5 Units/hr)

Glucose   Insulin rate
mMol/L     units/hr

 0 -  3.9      0
 4 -  6.9      1
 7 -  9.9      2
10 - 14.9      3
15 - 19.9      4
     20+       5
```

Time	Repeat		Message, File or Co
26/04/2006 12:28 pm	5 Minutes	🟥	ABC DIABETES --- re

Figure 13.4:
Screen showing in additon the Linux alarm window (bottom right) which opens by clicking on the ‘alarm’ icon on bottom bar.


PNG Image - 1024x768 Pixels - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
Fil
100
90
80
150
100
50
33
20
0
ain
Gases
larms
Logs
ne
10%
5%
0%
1000
500
0
1
0
2
Message - KAlarm
Close
Defer...

Location: file:/home/dick/camomile-stuff/screenshots/png50/snapshot51.png

22/04/2006 4:18 pm

DIABETES --- repeat blood sugar

```
13:24
13:24
13:24
13:25   alarm:Alarm On,CVP,25
13:27   alarm:Alarm Off,CVP,19
13:28   alarm:Alarm On,CVP,299
13:29   alarm:Alarm Off,CVP,---
13:32   alarm:Alarm On,BP,271 / 269
13:32   alarm:Alarm Off,BP,145 / 105
13:32   alarm:Alarm On,CVP,320
13:33   alarm:Alarm On,BP,297 / 47
13:33   alarm:Alarm Off,BP,128 / 45
```

```
SAT           99
FIO2          57

CO2 exp      4.2
CO2 insp     0.0
RR            10
TV exp       674
MVol         6.7

HR ecg       100
HR sat       100
CVP          ---
BP       90 / 43
NIBP     -- / --

Temp1      36.19
Temp2        ---
```

```
N2O exp     0.88
N2O MAC     0.01
vapour       SEV
Vap exp     1.57
Vap MAC     1.02
Total MAC   1.03
age           65
```

Done.

Figure 13.5:
Screen showing the pop-up diabetes alarm. Clicking the ‘close’ button causes the alarm to close and re-appear in 5 minutes. Once a blood sugar has been done, then a new interval alarm is set by clicking on one of the time-option buttons (20–60 minutes) on the diabetes widget.

Chapter 14

Data storage, files and formats

April 19, 2009 /allfiles/camomile/cam-book/ch-camdata.tex/

14.1 Introduction

The Camomile data program generates two groups of stored numeric data, known as D-data (raw data from the Datex monitor), and binlog-data (data consisting of <UnixTime><parameter-value> pairs; one file for each parameter).

14.2 Filenames—time/date encoding

The data files associated with each operation are held in a time/date encoded directory For example, the filename for a record started at 14.34 hrs on 26 November 2001 would be in the directory
/allfiles/camomiletop/theatredata/2001-Nov-26-1434

14.3 D-data.

This is the raw data from the Datex AS/3 monitor, and is saved to the file port-0.dnn in the main operation directory.
/allfiles/camomiletop/theatredata/2001-Nov-26-1434/port-0.dnn

Each data record consistes of 321 bytes, and is saved as a comma separated string of 8-bit ASCII codes (000–255).

The format of the D-data is as follows (note that each 5 second data episode is formatted into blocks of 19 lines, each line starting with an identifying code sequence (AS3000 → AS3018). The first line of each block gives the time and date information.

```
....
....
AS300,14:40:19,23-09-2004 (d/m/y) Datex AS/3 monitor
AS301,126,062,001,003,005,000,000,255,222,082,065,000,000,000,000,000,000,000
AS302,000,001,000,189,255,097,220,044,000,000,000,189,189,000,000,189,189,032
AS303,000,189,189,032,000,255,222,082,065,051,058,000,000,000,034,002,128,001
AS304,128,001,128,001,128,001,128,003,000,000,000,001,000,051,029,031,029,035
```

```
AS305,029,000,000,001,000,000,000,002,000,002,128,002,128,002,128,001,128,000
AS306,000,000,000,011,000,002,128,002,128,002,128,001,128,000,000,000,000,003
AS307,000,002,128,002,128,002,128,001,128,003,000,000,000,003,001,001,128,001
AS308,128,001,128,001,128,003,000,000,000,011,000,004,128,003,000,000,000,012
AS309,000,004,128,000,000,000,000,013,000,001,128,000,000,000,000,014,000,001
AS310,128,003,000,000,000,000,000,001,128,002,128,002,128,001,128,007,000,000
AS311,000,009,000,000,000,000,000,000,000,111,029,003,000,000,000,000,000,188
AS312,037,188,037,003,000,000,000,000,000,014,000,014,000,003,000,000,000,006
AS313,000,000,000,000,000,000,000,003,000,000,000,000,000,000,000,246,255,246
AS314,255,001,128,001,128,001,128,001,128,001,128,000,000,000,000,007,000,001
AS315,128,001,128,001,128,001,128,032,000,000,000,000,000,001,128,001,128,255
AS316,141,001,128,001,128,001,128,000,000,000,000,189,189,001,128,000,000,000
AS317,000,013,000,002,128,002,128,002,128,001,128,000,000,000,000,014,000,002
AS318,128,002,128,002,128,001,128,000,000,000,064,081,000,072,126
AS300,14:40:24,23-09-2004 (d/m/y) Datex AS/3 monitor
AS301,126,062,001,004,005,000,000,004,223,082,065,000,000,000,000,000,000,000
....
....
```

14.4 binlog

The Camomile data program stores the comma-separated <UnixTime><parameter-value> pairs (see example below) for each parameter in a separate file (a single file for the whole operation); for example the file for the systolic blood pressure is named bp-s.binlog. These files are stored in the /fields/ subdirectory, as follows:-
/allfiles/camomiletop/theatredata/2001-Nov-26-1434/fields/bp-s.binlog

```
....
1095947414,145.43
1095947419,144.38
1095947424,143.66
1095947429,142.75
1095947434,149.07
1095947439,140.99
1095947444,140.4
1095947449,147.14
1095947454,146.62
1095947459,138.84
1095947464,138.61
....
```

Later, each file is broken down into separate 1-hour files (called .gnn files; eg bp-s.g01,bp-s.g02. etc), preparatory to printing

14.5 Drug-data

The Camomile data program keeps a log of the operation, start time, end time, keyboard entries, entries from the pull-down menus (drugs, anaesthetists, surgeons), and details of Alarms ON and OFF, and bad checksums, as shown in the example below. This entry is written in a TeX format, and is further processed to obtain the printed-out form of the drug log which is placed in the patients notes.

```
%&camomile
%%Camomile (v 0.1_040413b[c:Apr 15 2004@12:10:32])
\BeginLog{2004-09-23,14:38:16}%
\VersionStamp{Camomile}{0.1\_040413b}{Apr 15 2004@12:10:32}%
%%  TruncateLog=0
\Note{192}{opened logfile "/home/dick/allfiles/camomiletop/theatredata/2004-Sep-23-1438/base.log"}
%
\Mark{2004-09-23,14:38:16}%
\EntryDevice{2004-09-23,14:38:16}{project}{start}%
%
\Mark{2004-09-23,14:39:34}%
\EntryAnaesthetist{E}{2004-09-23,14:39:26}{Dr R. W. D. Nickalls et al}{}%
%
\Mark{2004-09-23,14:44:24}%
\EntryDevice{2004-09-23,14:44:24}{datex as3}{bad checksum 204,172}%
%
\Mark{2004-09-23,14:44:29}%
\EntryDevice{2004-09-23,14:44:29}{datex as3}{bad checksum 204,172}%
%
\Mark{2004-09-23,15:16:31}%
\EntryDrug{2004-09-23,15:16:25}{Morphine}{2}{}%
....
....
\Mark{2004-09-23,15:17:23}%
\EntryDrug{2004-09-23,15:16:33}{Epidural = (marcain 0.25)  5mls}{}{}%
%
\Mark{2004-09-23,15:17:34}%
\EntryAlarm{E}{2004-09-23,15:17:34}{Alarm Off}{BP}{160 / 75}%
%
\Mark{2004-09-23,15:17:35}%
\EntryDrug{2004-09-23,15:17:24}{Epidural fentanyl 100 mcg}{}{}%
%
\Mark{2004-09-23,15:34:49}%
\EntryDrug{2004-09-23,15:34:38}{Gelofusin}{500 IN}{}%
%
\Mark{2004-09-23,16:32:33}%
\EntryDrug{2004-09-23,16:32:28}{Neostigmine + Glycopyrrolate}{}{}%
%
\Mark{2004-09-23,16:32:35}%
\EntryDevice{2004-09-23,16:32:35}{project}{stop}%
\Note{205}{closing logfile}%
%
\EndLog{2004-09-23,16:32:35}%
%%eof
```

Part IV

Data processing—inline printing module

Chapter 15

Printing module—overview

April 19, 2009 /allfiles/camomile/cam-book/ch-printover.tex/

15.1 Introduction

The anaesthesia data accumulated by the Camomile data-program is output and stored in the `/fields/` directory of the current operation directory (`$projdir`), in the form of `.binlog` files, each one associated with a given parameter field, containing a series of (⟨time⟩, ⟨parameter value⟩) pairs.

When the Camomile data-program terminates control returns to the coordinating Perl program `launchcam12.pl`, which currently coordinates the data processing preliminary to the physical printing of the Anaesthesia Record itself. The aim of the printing process is to access the stored data in the `/fields/` directory, and plot it in graphic form on A4 paper in such a way that each A4 sheet shows 1 hour of data.

All the data manipulation is done by the following small Perl programs which are stored in the `/.../camomiletop/datexsim/printfiles/` directory.

```
base2texd.pl       ... does some ASCII to TeX conversion to log file
cam2gnnh.pl        ... generates the .data and .gnn files
launchcam12.pl     ... runs the Camomile program
plotgnnk2.pl       ... coordinates printing module
printall.pl        ... prints the paper sheets
prtanes6.tex       ... TeX file for the graphs
prtdrug2.sty       ... TeX style option for printing module
prtdrug.tex        ... TeX file for the log file
```

We now address the printing process in some detail, covering the various steps from the raw `/field/` output data (acquired by the Camomile data-program) to the production of the paper endpoint—the Anaesthetic Record—which is placed in the patient notes. The full code of the eight or so Perl programs is listed in the subsequent chapters.

15.2 The start-time

A key piece of information required by the printing process is the start-time of the operation (or in practice, the start-time of data collection). The start-time is required for two main reasons as follows

- To define the directory name (*projdir*) of the current operation so all related information can be stored there. The start-time is determined by the Perl program `launchcam12.pl` by grabbing the Unix-time and Local-time. This start-time is then used to construct a 'time encoded directory' (TED) by passing the time parameter to the subroutine `tedtime()` resulting in a suitable dirctory string. For example a typical TED directory string is as follows.

  ```
  2004-Mar-18-11.23/
  ```

- To determine the number of 1-hour A4 printed records (i.e. we subtract the start-time from the time associated with the last recorded data item.

The folowing extracts from the Perl program `launchcam12.pl` illustrate the relevant steps in making the time encoded directory name.

```
#[launchcam12.pl]
...
# grab the starttime as GMT and Unixtime
$timenowgmt = localtime;
$timenowunix=time();
$projdir=tedname($timenowgmt);
# add the / at the end of the dir
# (so Camomile-program makes the /fields/ subdirectory
$projdir=$projdir."/";
...
...
sub tedname{
    ## returns a date/time encoded filename--> $projdir;
    my $startgmtstring=$_[0];
    ## format is:    Sun Jan 25 13:24:35 2004
    ## format is:    Sun Jan  5 13:24:35 2004
    ## note get two spaces after the Month if days <10
    # if two spaces in posn 8 and 9 then remove one
    if (substr($startgmtstring,7,2) eq "  ") {substr($startgmtstring,7,2," ")};
    ## now replace spaces with commas
    $startgmtstring =˜ tr/ /,/;
    ## make an array
    @stgmt=split (/[,]/, $startgmtstring);
    $day=$stgmt[0], $month=$stgmt[1], $date=$stgmt[2], $hms=$stgmt[3];
    $year=$stgmt[4];
    $noitems=$#stgmt+1;
    ## now extract the hh:mm:ss part to get the hh:mm
             @hhmmss=split (/[:]/, $hms);
             $hour=$hhmmss[0], $min=$hhmmss[1];
```

```
    ## force two-digit for date (= day-of-month)
    ## as unix gmt uses only 1 char if less than 10
    if ($date<10){$date="0".$date};
    ## format the datestring as 2004-01-22-1341
    $datestring="$year-$month-$date-$hour$min";
    return "/home/dick/allfiles/camomiletop/theatredata/"."$datestring";
    };
```

15.3 Running the Camomile data program

In practice the operation time encoded directory (project directory) is actually created by the Camomile data program. To this end the Camomile data program is passed the required project directory name (`$projdir`) at start-up. This is done using Camomile's `-P` command-line switch (together with the name of a required configuration file) as follows (note that this is a Perl program, and so the command has to be issued as part of the Perl `system()` command).

```
#[launchcam12.pl]
...
$conf="../conf2/c_as3rn.conf"
$projdir="/home/user/camomiletop/theatredata/2004-Mar-18-11.23/"
system(../tarballs/camomile-0.1_040411/camomile/camomile -A 1  -P $projdir  -c $conf");
```

15.4 After the Camomile data program exits

Once the Camomile data program has terminated, we then create a subdirectory in the project directory (called `/pdata/`—the 'p' indicating that this subdirectory relates to Printing data) to contain all the files required for printing as well as those generated during the printing process. While this directory can be placed anywhere, it is convenient during the current development period to keep all the files and directories relating to a given operation together, while at the same time keeping the camomile raw data separate from the derived processed data.

```
#[launchcam12.pl]
...
## create the new /pdata/ subdirectory
$projpdatadir=$projdir."pdata/";
mkdir $projpdatadir;
```

Start-time

Since various programs need to know the start-time (both in Unix-time and in GMT-time) we now make these times available by writing them to a special ASCII file (text file) called `starttime.dat`, which can then be read by any process needing this important information. The `starttime.dat` file is written by the program `launchcam12.pl`, as follows.

```
#[launchcam12.pl]
...
```

```
open (outfile1, ">$destinationfilename1")
            ||die "ERROR: can’t create file <starttime.dat>\n";
print (outfile1 "%% file name: startfile.dat:  created $timenowgmt\n");
print (outfile1 "%% file generated by <launchcam.pl> RWD Nickalls\n");
print (outfile1 "%% file read by <plotgnnk2.pl> \n");
print (outfile1 "projectdir,$projdir\n");##use commas no spaces
print (outfile1 "starttime,$timenowunix,$timenowgmt\n");##no spaces
close (outfile1);
```

A typical starttime.dat produced by this code is as follows.

```
%% startfile.dat:  created Mon Mar 29 10:26:28 2004
%% file generated by <launchcam.pl> RWD Nickalls
%% file read by <plotgnnh.pl>
projectdir,/home/dick/allfiles/camomiletop/theatredata/2004-Mar-29-1026/
starttime,1080552388,Mon Mar 29 10:26:28 2004
```

Note that we deliberately use commas to separate the key data-strings in the last two lines, as we can then easily manipulate the data-strings using the Perl split command for putting the relevant data-strings into arrays.

Copy required software tools

We now copy a suite of files (required for the printing process) from the /datexsim/printfiles/ directory to the /pdata/ directory.

```
#[launchcam12.pl]
...
## now copy all the <printfiles> tools to the /projdir/pdata/ dir
print "copying files from   /datexsim/printfiles/  to ..../project/pdata/ \n";
system ("cp -v ./printfiles/*.*  $projpdatadir");
print "...... done\n";
```

Now everything is in place so we now move to the /pdata/ directory in preparation for the next phase—data processing—and call the Perl coordinating program plotgnnk2.pl as follows.

```
#[launchcam12.pl]
...
chdir $projpdatadir;
```

Data processing—launch program plotgnnk2.pl

The next phase is to process all the data and generate all the necessary .dvi, .pdf and .ps files so we can then print them out at a suitable time (usually at the end of the operation), and keep copies for archiving. All the data processing is coordinated by the Perl program plotgnnk2.pl, so the next thing it to launch this program as follows.

```
#[launchcam12.pl]
...
print "... now calling   <perl ./plotgnnk2.pl> \n";
system ("perl ./plotgnnk2.pl");
```

During the data processing we write comments to the screen and also write detailed comments to the log file printlog.txt. In addition we keep a detailed log of the start times for a number of parameter files as these files are created in 1-hour chunks—this data is collected in the file timefile.txt.

15.5 Reading the starttime.dat file

We read the starttime.dat file right at the begining of data processing, in order to access (a) the unix start-time, and (b) the name of the operation directory. This information is on the first and second data-lines in the file. Both these parameters are passed by the coordinating program plotgnnk2.pl to the program cam2gnnh.pl.

15.6 Accessing the Camomile-stored data

Both these parameters are passed by the coordinating program plotgnnk2.pl to the program cam2gnnh.pl which creates all the parameter .data files, and from these generates all the .gnn files.

a Access the parameter fields (camomilefields2tex.c)

The output data is stored by the Camomile data program in the project sub-directory /fields/ and so our first task is to access the data in a suitable format using the software access tool camomilefield2tex (a C program). This utility allows us to grap the data and store it in a form suitable for post-processing. Although the original data is currently stored in ASCII files, this may well change during development. An example of the current sat.binlog structure is as follows (sat.binlog).

```
## sat.binlog
1071580231,92
1071580236,92
1071580241,93
1071580246,93.5
1071580251,93
1071580256,93
1071580261,92.5
1071580266,92
...
...
```

Consequently, accessing the data via an access tool has the advantage that the post-processing can proceed independent of the particular data storage format.

The C program camomilefield2tex is a utility to access the stored data in a form suitable for post-processing (unfortunately this is awkward since it requires access to the starttime.dat file, and so this utility has since been simplified and rewritten in Perl so it gets the time by reading the data file itself, and is currently used in the stand-alone printing module—described in the next chapter). The current version of the program comes as camomilefield2tex-0.1_040411.tgz which expands to /tarballs/camomilefield2tex-0.1_040411.tar.gz. To install type: (do the make install as root).

```
$  ./configure
$  make
#  make install
```

To get the help info type:

```
$  camomilefield2tex  --help
```

which gives:

```
 -p <path>               path of the /project/ directory
-f <parameter>          parameter field name
-o <filename>           output file name
-s <style>              output style (tex, gnuplot)
-V                      version
--help                  this help information
```

Example of use.

```
camomilefield2tex -p $projdir  -f sat  -o sat.data  -s gnuplot
```

We use the style [gnuplot] as this gives simple comma-separated fields which can be easily parsed by Perl.

b Calling the camomilefield2tex.c utility

The list of required parameter names is held in the array @paramname defined at the beginning of the program, as follows. In fact for thoracic anaesthesia we also need to display the ventilation plateau pressures (to be incorporated later).

```
#[cam2gnnh.pl]
...
@paramname = ("bp-s", "bp-d","ecg-hr","sat-hr","cvp","nibp-s","nibp-d",
               "sat",
               "o2-insp", "n2o-exp",
               "co2-exp",
               "tv-exp","co2-rr",
               "vap-insp", "vap-exp", "mac-big" );
```

For each parameter-name we then generate a datafile by calling the utility program camomilefield2tex (the next line then generates all the .gnn files by calling the subroutine makeGnnfiles—see next section).

```
#[cam2gnnh.pl]
...
# get each parameter in turn
for ($j=0; $j<=$#paramname; $j=$j+1 )
     {
      $ffile = $paramname[$j];
      $ofile = $projdir."pdata/"."$paramname[$j]".".data";
--->  system ("camomilefield2tex -p $projdir  -f $ffile  -o $ofile  -s gnuplot") ;
      ## now create all the .gnn files for the parameter
      makegnnfiles($paramname[$j]);
     }
```

The above camomilefield2tex command outputs all the stored parameter data for a given parameter into a file consisting of the following four comma separated fields on each line into the specified output file.

```
unix-time, gmt-time, elapsed-time, parameter-value
```

A typical example of the sat.data file is as follows. Note that the elapsed-time parameter on the first line is zero, and that both the unix-time and the elapsed-times increase in steps of 5 seconds (data is output from the Datex monitor every 5 seconds).

```
#[sat.data]
1071580231, 2003:12:16:13:10:31,  0, 92.000000
1071580236, 2003:12:16:13:10:36,  5, 92.000000
1071580241, 2003:12:16:13:10:41, 10, 93.000000
1071580246, 2003:12:16:13:10:46, 15, 93.500000
1071580251, 2003:12:16:13:10:51, 20, 93.000000
1071580256, 2003:12:16:13:10:56, 25, 93.000000
1071580261, 2003:12:16:13:11:1,  30, 92.500000
1071580266, 2003:12:16:13:11:6,  35, 92.000000
...
...
```

Armed with the above .data file for a given parameter, then we proceed to generate from this a series of 1-hour .gnn files, as described in the next section.

c Generate 1-hr .gnn files with subroutine makegnnfiles()

This role of this subroutine is to generate from the above parameter .data file (which may contain many hours of data) a series of 1-hour .gnn files suitable for use by the GNUplot graphing program. The makegnnfiles() subroutine is part of the Perl program cam2gnnh.pl (which is itself called by the co-ordinating Perl program plotgnnk2.pl). The subroutine is called with the field parameter name as follows.

```
makegnnfiles($paramname[$j]);
```

Calling the subroutine makennnfiles() converts each of the raw output parameter data-files (.data files) into a series of 1-hour two-column space-separated data-files suitable for accessing by gnuplot. For example, a 4-hr sat.data file would be converted into four 1-hour files as follows: sat.g01, sat.g02, sat.g03, sat.g04.

The makegnnfiles() subroutine also makes the elapsed time for each file relative to the beginning of each hour by using the new computed “start-time” for each file as the zero-time, i.e. elapsed time within a .gnn file will run from 0—3599 secs (i.e. just 1 hour). We have three ⟨space⟩ delimited fields namely ⟨elapsed-time-(local)⟩, ⟨parameter⟩, ⟨unix-time⟩.

The subroutine figures out how to split up the .data file into 1-hour chunks by comparing the difference between the operation start-time and the unix-time on each line. Note that both the unix-time and gmt-time are passed to the cam2gnnh.pl program by the calling program (plotgnnk2.pl). If the elapsed time exceeds 1-hour, then the current .gnn file is closed, and the next one opened etc.

In practice, however, data is only retained at approximately 30–45 second intervals (this interval can be varied depending on the requirements). So although the data is originally stored every 5 seconds, the actual printed data is thinned out somewhat, purely because there is a limit to what density of data can usefully be printed to the Anaesthesia Record. If better resolution is required, then higher resolution printing can be performed at a later date.

```
#[cam2gnnh.pl]
...
  sub makegnnfiles {
       ## get the starttimeUNIX  passed from commandline value --> @ARGV
       ## the starttimeUNIX is obtained originally from file <starttime.dat>
        $starttimeunix = $ARGV[0];
        # passing only one name into array
       my ($file) = @_;
       print "---processing parameter [$file] \n";
       # add the file-ending .dat
       $infilename=$file.".data"; ###*
       print "---the input filename is [$infilename] \n";
       open (infile, "<$infilename")||die "ERROR: can’t find file $infilename \n";
       # now make time-dependent out filename
       # start with hour set to zero
       $hour=0;
       #---------------
       # start inputting lines of data
       #need to get the time associated with  line 1
       #
     $interval=45; #secs
     $oldelapsedtime=0;
    LINE: while (<infile>){
          next LINE if /^#/;  #skip comments
          next LINE if /^%/;  #skip comments
          next LINE if /^$/;  #skip blank lines
          # grab the whole line as a string
          $dataline = $_;
          # place the params into an array
          @value=split (/[,]/, $dataline);
          # print " $value[0]   $value[1]  $value[2]\n";
         # assign the elapsedtime and param values
         $unixtime=$value[0];
         $gmtime=$value[1]; #GMT yyyy:mm:dd:hh::mm:ss
         $elapsedtime = $value[2]; #elapsed-time (secs)
         $paramvalue=$value[3];
         chomp($paramvalue);  # remove the line-ending to help maths
         #--------------------
         # multiply the rr values by 50 (to make them fit range 0--1000)
         if ($file eq "co2-rr"){$paramvalue=$paramvalue * 50};
         #----------------
         ## save data only every $interval (secs)
         $elapsedtime=$unixtime-$starttimeunix; ## determine true elapsedtime
         if ($elapsedtime < $oldelapsedtime +$interval)
            {next LINE}
            else{$oldelapsedtime = $elapsedtime}
        #---------------
    #now print data into 1 hr files
    # make NewElapsed time relative to begining of new hour
    # hour 1 = first real hour
    # hour will be zero on first run thro algorithm so goes to  else...
    if  ($elapsedtime <$hour *3600){
      $space="  ";
      # calculate new elapsed time from begining of new hour
      $newet=$elapsedtime-3600*($hour -1);
      print (outfile "$newet $space $paramvalue $space $unixtime\n");
        }
    else{
      # close existing gnn file and open a new one (gnn+1)
      close (outfile);
      $hour=$hour + 1;
      #use two digits for the filename extension eg .g04
      if ($hour <10){$hour="0".$hour};
      $gnudatafilename=$file.".g".$hour;
      print "---the new output filename = $gnudatafilename \n";
      open (outfile,">$gnudatafilename")||die "can't open the outfile \n";
      # write some headers to the outfile
      $outfileheader1="## Camomile gnuplot datafilename = $gnudatafilename";
      $outfileheader2="## date?";
      print (outfile "$outfileheader1\n");
      print (outfile "$outfileheader2\n");
      # write  info to the timefile
      print (timefile "$hour, $unixtime, $gmtime, $gnudatafilename\n");
      $space=" ";
      # calculate new elapsed time from begining of new hour
      $newet=$elapsedtime-3600*($hour-1);
      print (outfile "$newet $space $paramvalue $space $unixtime\n");
      }#end of else{
    }#end o while
   close (infile);
   close (outfile);
}#$
```

A typical example of a `.gnn` file (the file `sat.g03`) is as follows. There are three fields (elapsed-time, parameter-value, unix-time) which are space-separated. In this example the data was collected every 30-40 seconds or so and the elapsed-times are seen to be 31, 76, 121, ... etc. The unix-time field is retained as a check. The `03` in the filename extension `.g03` indicates that it represents data collected during the third hour.

```
##[sat.g03]
31      87.500000    1080559619
76      88.000000    1080559664
121     89.500000    1080559709
166     93.000000    1080559754
211     94.500000    1080559799
256     95.000000    1080559844
```

```
301     95.000000     1080559889
346     95.000000     1080559934
391     95.000000     1080559979
436     94.500000     1080560024
...
...
```

d The log-file (timefile.txt)

Concurrently with the previous process, the program cam2gnnh.pl creates the timefile.dat file which holds the start-times for each of the .gnn files (see below). This file is very useful as a check on the functioning of the cam2gnnh.pl program.

```
#[timefile.txt]
...
...
01, 1071580301, 2003:12:16:13:11:41, bp-s.g01
02, 1071583865, 2003:12:16:14:11:5, bp-s.g02
03, 1071587465, 2003:12:16:15:11:5, bp-s.g03
...
...
01, 1071580276, 2003:12:16:13:11:16, sat.g01
02, 1071583840, 2003:12:16:14:10:40, sat.g02
03, 1071587440, 2003:12:16:15:10:40, sat.g03
...
...
```

e The base.log file (baselog.data)

After processing all the parameter fields → .gnn files we then access (extract) the anaesthetists log file (base.log) using the camomilefielf2tex utility as before, only this time using the .l switch and the -s tex option since we are wanting to access a log file.

```
#[cam2gnnh.pl]
...
system ("camomilefield2tex -p $projdir  -l base   -o baselog.data  -s tex") ;
```

Note that since we are running this command from within the /pdata/ subdirectory then the default location for the output files is the current directory.

15.7 Write the GNUplot scripts for each graph

Each 1-hour page of the Anaesthesia Record consists of six separate graphs, each showing a time plot of several parameters. Each spearate graph requires its own so called .gnu file (script) which sets up the graph structure and plots each parameter inside it. All this is coordinated by the Perl program plotgnnk2.pl, and so we will look in more detail how this is done.

Each parameter to be plotted has its own .gnn[1] parameter file (not absolutely necessary but very convenient in practice—see previous section). To facilitate this, we

[1] Not to be confused with the .gnn data files.

arrange that each 1-hour .gnn file has its elapsed time starting from zero, which greatly simplifies the plotting process.

The most difficult part of generating the .gnu files (one file per graph) is to construct the time-base, such that all .g01 parameter files are plotted on graphs showing the start and end times of the first hour, and also of the 15-minute vertical lines which are also drawn.

The timebase parameter $timeline

The time markings along the *x*-axis are drawn using the GNUplot set xtics() command which, in this case, takes a complicated parameter which is the string $timeline. In practice, for each hour the particular time-base used will be the same for all graphs drawn using parameters values from files having the same gnn value; say, .g02 files for example.

The following code determines this string for each hour, tailoring it to accomodate the time interval associated with each .gnn value, so as we move from one hour to the next then the time associated with each hour increases accordingly.

```
#[ploggnnk2.pl]
...
# determine the earliest start time from G01 files in timefile.dat file
# put the start-time-GMT[year:month:day:hrs:mins:sec] into an array
# then determine how many  hours worth of Gnn files there are
# $st is the start-time hh:mm:ss from the <starttime.dat> file (see above)
$JJ=gnnmax("01"); ## returns gnnMax
print (printlog "start-time = [$st] \n");
print (printlog "GnnMax = $gnnmax \n");
# extract the separate hh, mm, ss values
@start_time= split (/[:]/, $st);
$starthour = $start_time[0];
$startminute=$start_time[1];
$startsecond=$start_time[2];
#------------
# now print all the graphs for all Gnn files from 01 to GnnMax
for ($gnn=1; $gnn<=$gnnmax; $gnn = $gnn+1)
    {
    # first determine time in secs to the begining of next full hour
    $deltah = 3600 - ($startminute*60 + $startsecond);
    # generate correct start-hour depending on Gnn value
    $h = $starthour + $gnn;
    $hminus1=$h-1;  $hplus1=$h+1;
    if ($h==0) {$hminus1=23};
    if ($h==23) {$hplus1=0};
    $q=900; $qq=1800; $qqq=2700; $qqqq=3600;
    # force 24hour clock
    if ($h <10){$h="0".$h};
    if ($hminus1 <10){$hminus1="0".$hminus1};
    if ($hplus1 <10){$hplus1="0".$hplus1};
    $deltahminusqqqq=$deltah-$qqqq;
    $deltahminusqqq=$deltah-$qqq;
    $deltahminusqq=$deltah-$qq;
    $deltahminusq=$deltah-$q;
    $deltahplusqqqq=$deltah+$qqqq;
    $deltahplusqqq=$deltah+$qqq;
    $deltahplusqq=$deltah+$qq;
    $deltahplusq=$deltah+$q;
    #---------------
    $t1 = "$hminus1.00"." $deltahminusqqqq";
    $t2 = "$hminus1.15"." $deltahminusqqq";
    $t3 = "$hminus1.30"." $deltahminusqq";
    $t4 = "$hminus1.45"." $deltahminusq";
    $t5 = "$h.00"." $deltah";
    $t6 = "$h.15"." $deltahplusq";
    $t7 = "$h.30"." $deltahplusqq";
    $t8 = "$h.45"." $deltahplusqqq";
    $t9 = "$hplus1.00"." $deltahplusqqqq";
    $timeline="$t1,$t2,$t3,$t4,$t5,$t6,$t7,$t8,$t9";
```

Armed with the time-base we can start making (write to) the .gnu files. In the following we illustrate the code for writing the sat.gnu script file (which will be processed by the GNUplot program eventually). First we check that the 'hour' value incorporated into the .gnn string always has two digits (i.e. 4 → 04 and hence we obtain g04), and defining the graph height to be used, we then open the output file and proceed.

```
#[plotgnnk2.pl]
...
# first make sure the gnn string has three characters
if ($gnn <10){$gnn="0".$gnn};
# define the graph heights
$smallheight=0.43; ## for all other graphs
...
...
## now create the sat file -------------------------
open(satfile, ">plot-sat.gnu")
              ||die "ERROR: can't open  plot-sat.gnu file\n";
   print (satfile  "#!/usr/bin/gnuplot\n");
   print (satfile  "# plot-sat.gnu script made by plotgnnk2.pl\n");
   print (satfile  "set terminal latex\n");
   print (satfile  "set output \"plot-sat.pic\" \n");
   print (satfile  "set size 1.40,$smallheight\n");
   print (satfile  "set xtics($timeline)\n");
   print (satfile  "set ytics (\"\" 80,\"\" 90,\"\" 100)\n");
   print (satfile  "set y2tics (80, 90, 100)\n");
   print (satfile  "set nokey\n");
   print (satfile  "set grid\n");
   print (satfile  "xmin=0;xmax=3600\n");
   print (satfile  "ymin=80; ymax=100\n");
   print (satfile  "plot [xmin:xmax][ymin:ymax] \\\n");
   $satfilename="sat".".g".$gnn;
   $fo2filename="o2-insp".".g".$gnn;

   if (-e $satfilename)
        {print (satfile  "     \"$satfilename\" using 1:2 with linespoints 4  8,\\\n")}
        else {print (printlog " ---**** no sat.gnn files\n")};

   if (-e $fo2filename)
        {print (satfile  "     \"$fo2filename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no fo2.gnn files\n")};

   $dummyline = "      -20 with lines 1  # dummy line";
   print (satfile  "$dummyline \n");
   close (satfile);
```

It is significant here that in the last few lines of this code we have used the line

```
print (bpfile  "$dummyline \n");
```

This is to solve a problem which would arise should one or more of the parameter files not exist, as in this situation GNUplot graph plotting would fail since it requires that the final line must not have a comma at the end. By using a 'dummy' line (which has no comma and only plots a point below the graph (-20) and hence is never visibly plotted) as the final line, we are able to handle the failure of all or some of the parameter lines which therefore can all have a terminal comma.

15.8 Run GNUplot on all the .gnu files

Once all the .gnu files have been written, then we run GNUplot on each one to generate each figure in $\LaTeX\,2_\varepsilon$ picture format. Each printed sheet has five figures arranged horizontally from top to bottom. The legends are on the right hand side so they are not obscured by the binding when placed in the patient notes.

```
#[plotgnnk2.pl]
...
print (printlog "---running GNUPLOT on all the .gnu files\n");
system ("gnuplot plot-bp.gnu");
system ("gnuplot plot-sat.gnu");
system ("gnuplot plot-fo2.gnu");
system ("gnuplot plot-co2.gnu");
system ("gnuplot plot-tv.gnu");
system ("gnuplot plot-vap.gnu");
print (printlog "..........GNUPLOT ... done\n");
```

15.9 Write the header line for the printouts

Each printed sheet has a header indicating the start-time (GMT and unix) and the .dvi filename (which indicates which hour the sheet refers to) as follows:

```
Record start-time: Thu Feb 12 12:11:19 2004   unix 1076587879  anes-04.dvi
```

This is written to a file (`header.dat`) as follows, and then read back when needed for printing.

```
#[plotgnnk2.pl]
...
print "writing the <gnnheader.dat> file to contain header for Anes record   \n";
open (outfile5, ">gnnheader.dat")||die "ERROR: can't create file <gnnheader.dat>\n";
$timenow = localtime;
print (outfile5 "%% gnnheader.dat:  created  $timenow\n");
print (outfile5 "%% file generated by <plotgnnk2.pl> RWD Nickalls\n");
$fname="anes-".$gnn.".dvi";
print (outfile5 "\\header{$starttimeunix}{$originalgmt}{$fname}\n");
close (outfile5);
print "......<gnnheader.dat>.... done\n";
```

15.10 Typeset the graphic pages using LaTeX 2ε

We now typeset the graph pages and create the output formats `.dvi`, `.ps`, and `.pdf` on the fly. The TeX file for the graphs is `prtanes6.tex`. The style option is `prtdrug2.sty`. We create the PostScript files using `dvips`. We create the `.pdf` files using `pdflatex`.

```
print (printlog "---running LATEX on prtanes6.tex\n");
system ("pslatex prtanes6.tex");
$dvifilename="anes-".$gnn.".dvi";
# copy the .dvi file to  have a gnn.dvi filename
system ("cp -v prtanes6.dvi $dvifilename");
# make the .ps files
$psfilename="anes-".$gnn.".ps";
system ("dvips $dvifilename -o $psfilename");
print (printlog "..........LATEX ...done\n");
# now make the pdf files
system ("pdflatex prtanes6.tex");
$pdffilename="anes-".$gnn.".pdf";
# copy the .pdf file to include a ..gnn.pdf filename
system ("cp -v prtanes6.pdf $pdffilename");
```

15.11 Typeset the drug file using LaTeX 2ε

Processing the drug file (log file) is slightly more complicated owing to the fact that the typesetting is done using LaTeX 2ε. Consequently, since the anaesthetists can enter data using the keyboard we need to filter out all non-TeX material (essentially to 'escape' certain ASCII characters; for example, we would modify % *rightarrow* \% etc). This conversion is currently done by the Perl program `base2texd.pl`, which processes the original log-file (`baselog.data`) to the 'filtered' file `baselognew.data`.

We now typeset the 'filtered' drug-file and create the output formats `.dvi`, `.ps`, and `.pdf` on the fly as before. The TeX file for the graphs is `prtdrug.tex`. The style option is `prtdrug2.sty`. We create the PostScript files using `dvips`. We create the `.pdf` files using `pdflatex`.

```
# process the baselog.data file
system ("perl ./base2texd.pl");
# now latex the prtdrug file
system ("latex ./prtdrug.tex");
# copy the .dvi file to  have a anes-drug.dvi filename
system ("cp -v prtdrug.dvi anes-drug.dvi");
# make the PS version of the .dvi file
system ("dvips anes-drug.dvi -o anes-drug.ps");
# make the pdf file
system ("pdflatex prtdrug.tex");
# copy the .pdf file to  have a gnn.pdf filename
system ("cp -v prtdrug.pdf anes-drug.pdf");
```

15.12 Printing the paper sheets

Finally, we print out all the sheets making up the Anaesthesia Record. This currently consists of one or more 'drug' sheets (the log file), together with a number of 1-hour graphic sheets presenting the measured parameters. These are usually printed out in the operating theatre and placed in the patient notes.

In practice a small Perl program (`printall.pl`) sends the final files to the printer in reverse order as follows.

```
#!/usr/bin/perl
# printALL.pl
# do graphs in reverse order
if (-e "anes-10.dvi") {system("dvips anes-10.dvi")} else{};
if (-e "anes-09.dvi") {system("dvips anes-09.dvi")} else{};
if (-e "anes-08.dvi") {system("dvips anes-08.dvi")} else{};
if (-e "anes-07.dvi") {system("dvips anes-07.dvi")} else{};
if (-e "anes-06.dvi") {system("dvips anes-06.dvi")} else{};
if (-e "anes-05.dvi") {system("dvips anes-05.dvi")} else{};
if (-e "anes-04.dvi") {system("dvips anes-04.dvi")} else{};
if (-e "anes-03.dvi") {system("dvips anes-03.dvi")} else{};
if (-e "anes-02.dvi") {system("dvips anes-02.dvi")} else{};
if (-e "anes-01.dvi") {system("dvips anes-01.dvi")} else{};
# print the drug sheet last (on top)
if (-e "anes-drug.dvi") {system("dvips anes-drug.dvi")} else {};
```

Chapter 16

Typesetting programs

ch-prtanes.tex

16.1 prtanes6.tex

```
\documentclass[a4paper]{article}
\usepackage[dvips]{color,graphicx}
%\usepackage[pdftex]{color,graphicx}
\usepackage{times}
\usepackage{latexsym}  %% for \Box symbol
%%%%\usepackage{graphicx} %% for rotate[]{} in dvips/pdf only
\usepackage{prtdrug2}
\usepackage{miscrwdn} %% needed for cupBOX and cupframebox

%% redefine the \tenrm command output by GNUplot
\newcommand{\tenrm}{\rmfamily\normalsize}

%%------symbols modified from my medicine.sty----------
\newcommand{\jotwo}{\ensuremath{\mbox{\scriptsize O}_2}}
\newcommand{\jcotwo}{\ensuremath{\mbox{\scriptsize CO}_2}}
\newcommand{\etcotwo}{ET\ensuremath{_{\jcotwo}}}
\newcommand{\fiotwo}{F\ensuremath{\mbox{\textsc{i}}_{\jotwo}}}
\newcommand{\ntwoo}{\ensuremath{\mbox{N}_2}\mbox{O}}
%%---------------
%%

\voffset -1.75cm
\oddsidemargin -11mm
\textwidth 20cm
\textheight 25cm   %% was 25.5

\begin{document}
%% note that all the empty lines are essential for the layout
%% as \vspace{} requires a preceeding emptyline
```

```
\thispagestyle{empty}
%%----------------------------------------------
\vspace*{-1.8cm}

\newcommand{\patientlabel}{%
        \framebox{\rule[-10mm]{0cm}{3.3cm}%
        \hspace{2.2cm}Patient label\hspace{2.2cm}}}

\noindent\hspace{10.1cm}\patientlabel

\vspace{-3.5cm}
\noindent\hspace{2.3cm}{\color{blue}\LARGE AN{\AE}STHESIA RECORD}

\vspace{3mm}
\noindent\hspace{5.2cm}\textsf{Nottingham City Hospital} %% 2.3cm

\noindent\hspace{5.0cm}\hspace{2.27cm}{\color{blue}\textsf{NHS Trust}}

%------
\vspace{1.7cm}
%%==========date/time/file======================

\input{gnnheader.dat} %% contains starttime data for header

%% the input file contains a line with 3 parameters
%% starttimeunix, starttimegmt, gnn .dvi filename

%%=============================================================
\vspace{-2mm}
\noindent  \input{plot-bp.pic}\hfill
%*************************

%***********************
\vspace{-4mm}
\noindent\input{plot-sat.pic}\hfill
%******************

%*************************
\vspace{-4mm}  %-20
\noindent\input{plot-fo2.pic}\hfill
%******************

%*************************
\vspace{-4mm}
\noindent\input{plot-co2.pic}\hfill

%******************

%*************************
\vspace{-4mm}
```

```
\noindent\input{plot-tv.pic}\hfill
%%-------------------------------------------------------
%% now put on the right axis for Resp rate (0, 5,10,15,20).

 \vspace{-32.5mm} \noindent\hspace{158.5mm} 20 $\bullet$

 \vspace{1.4mm}\noindent\hspace{158.5mm} {15}

 \vspace{1.4mm}\noindent\hspace{158.5mm} {10}  %% was .8mm

 \vspace{1.4mm}\noindent\hspace{159mm} {5}

 \vspace{1.4mm}\noindent\hspace{159mm} {0} %% was 189
%

\vspace{-4mm}
%*************************

\vspace{7mm}
\noindent\input{plot-vap.pic}\hfill
%******************

%%==========labels=====================
\vspace{-19.4cm}%
\hspace{16.75cm}%   was 16.5
\begin{minipage}{2cm}
%%---BP---
inv BP $\circ$

NIBP $\Box$

\vspace{6mm}
HR$_{oxim}^{\bullet\mbox{--}\bullet}$

HR$_{ecg}^{\bullet}$

\vspace{5.5mm}

CVP ---
%------SAT----------

\vspace{18.5mm}
SAT $\circ$

\vspace{6.5mm}
\fiotwo \  $\bullet$
%%-------------fio2----

\vspace{12.1mm}
\ntwoo \ $\Box$
```

```
\vspace{3.2mm}
\fiotwo \  $\bullet$

\vspace{3.2mm}
P$_{plateau}^{\ \textstyle\circ}$
%-------------co2--------

\vspace{-2mm} %%***

\vspace{22mm}
%%ET$_{CO_2}$
\etcotwo \ $\diamond$
%-------------TV-----

\vspace{25.2mm}
TV$_{exp}^{\ \Box}$


\vspace{1.4mm}
RR $\bullet$
%%---------------vap----

\vspace{15mm}
VAP$_{insp}^{\ \ldots}$

\vspace{2mm}
VAP$_{exp}^{\mbox{ ---}}$

\vspace{2mm}
MAC$_{age}^{\  \Diamond}$
\end{minipage}


%%==========footnote==============================
\vfill

{\noindent}\rule{8cm}{0.5pt}

{\footnotesize
\noindent\copyright\ RWD Nickalls, S Dales \& A Nice 1994--2004: {\sc an{\ae}sthesia record system
{\newline}{\sc email:}{\textit{dicknickalls@compuserve.com}
}

%%------------------------------
\end{document}
```

16.2 prtdrug2.sty

```
%%%%%%%%%%%%%%%%%%%%%%
%% prtdrug2.sty
%% rwd nickalls April 15, 2004
%% LaTeX version + modifiction of Simon’s Camomile-record.sty
%%------------------
\typeout{***************************************************}%
\typeout{* This is prtdrug2.sty <04 Feb 2004>}%
\typeout{* Copyright (c) Camomile Group 2003-4}%
\typeout{* Written by RWD Nickalls & Simon Dales}%
\typeout{***************************************************}%
%---------------------
\newcommand{\n}{{\par\vspace{0.15\baselineskip}}}%
%---------------------
\newcommand{\BeginLog}[1]{\noindent{\bfseries Begin Log at #1\vspace{0.5\baselineskip}\hrule\vspac
%---------------------
\newcommand{\EndLog}[1]{\strut\vspace{-0.7\baselineskip}\hrule\vspace{0.5\baselineskip}\noindent{\
%---------------------
\newcommand{\VersionStamp}[3]{}% do nothing
%% #1#2#3 = {Camomile}{0.1\_040120}{Feb  3 2004@15:53:15}
%%\newcommand{\VersionStamp}[3]{\noindent{\bfseries Computer Program:} #1; Version %%\url{#2}, #3\
%---------------------
\newcommand{\Note}[2]{\noindent{\bfseries Note} (#1):\ #2\n}%
%---------------------
\newcommand{\Mark}[1]{} %% do nothing%
%---------------------
%---------------------
\newcommand{\EntryDevice}[3]{} %% do nothing%
%-------------------------
%\newcommand{\EntryAlarm}[5]{\noindent#2\myspace{\bfseries Alarm:}\ \ (#4: $#5$)\n}%
\newcommand{\EntryAlarm}[5]{}%  do nothing
%%#1#2#3#4#5 { E,time,alarmon/off, alarm, value}
%---------------------

\newcommand{\myspace}{\hspace{6mm}} %% two spaces
%-------------------------
%\newcommand{\EntryDrug}[4]{\noindent{\bfseries Drug:} #1, (#2, #3)\n}%
%%\def\EntryDrug#1#2#3#4{% time,drug,qty,comment
\newcommand{\EntryDrug}[4]{\noindent#1\myspace{\bfseries Drug:}\ \ #2 #3\n}%
%---------------------
\newcommand{\EntryTimer}[4]{%
    \count30=#3  %% seconds  (see Knuth p 118)%%
    \divide\count30 by 60 %% gives the minutes%%
    \noindent#1\myspace{\bfseries Timer:}\ \ interval set to \the\count30\ mins  (#4)\n}%
%%\def\EntryTimer#1#2#3#4{time0,time1,delay,comment
%----------------------------------
\newcommand{\EntryTimerDiabetes}[4]{%
   \count30=#3  %% seconds  (see Knuth p 118)%%
```

```
    \divide\count30 by 60 %% gives the minutes%%
  \noindent#1\myspace{\bfseries Timer (diabetes):}\ \ review in {\the\count30\ mins} (#4)\n}%
%%% note Simon actually has 5 fields for diabetes timer
%%\def\EntryTimerDiabetes#1#2#3#4{% time0,time1,delay,comment
%----------------------------------------------------------
\newcommand{\EntryAnaesthetist}[4]{\noindent#2\myspace{\bfseries An{\ae}sthetist:}\ \ #3\n}%
%% #1#2#3#4{type,time,name,comment}
%----------------------------------
\newcommand{\EntrySurgeon}[4]{\noindent#2\myspace{\bfseries Surgeon:}\ \ #3\n}%
%% #1#2#3#4{type,time,name,comment}
%------------------------------------------------------------------
\newcommand{\EntryPatientEvent}[6]{\noindent#1\myspace{\bfseries Patient:}\ \ #4 yrs, #2 kg, #3 cm
%%#1#2#3#4#5#6{time,mass,height,age,isMale,comment
%------------------------------------------------------------------
\newcommand{\EntryPatientEventJ}[7]{\noindent#1\myspace{\bfseries Patient:}\ \ #5 yrs, #3 kg, #4 c
%%#1#2#3#4#5#6#7{comment,time,mass,height,age,(M/F), Jobno
%------------------------------------------------------
\def\Conc#1#2{% legend,value
  #1=#2%
  }
%-------------
\def\Dosage#1#2{% legend,value
  #1=#2%
  }
%%-----------------------------------------------
\newcommand{\EntryBloodLoss}[3]{\noindent#1\myspace{\bfseries Blood Loss:}\ \  #2 #3\n}%
%%\def\EntryBloodLoss#1#2#3{% time,amount,comment
%--------------------------------------------
\newcommand{\EntryUrine}[3]{\noindent#1\myspace{\bfseries Urine output:}\ \ #2 #3\n}%
%%\def\EntryUrine#1#2#3{% time,amount,comment
%------------------------------
\newcommand{\EntryComment}[2]{\noindent#1\myspace{\bfseries Comment:}\ \
{$\left\{\parbox{10cm}{#2}\right.$}\n}%
%
%{\parbox{10cm}{#2}}\n}%
%%\def\EntryComment#1#2{% time,comment
%%-----------------------------
%%======================prtanes stuff here=================
%% header for the prtanes graph file
\newcommand{\header}[3]{\vspace{3mm}
         \hfill Record start-time: #2\hspace{5mm}unix #1
 \hspace{5mm}#3\hspace{3.3cm}
 \vspace{3mm}
 }
%% uses the three parameters #1#2#3 ={ unixtime, gmttime, gnnfilename}
%%eof
```

16.3 prtdrug.tex

```
%% prtdrug.tex
%% testing inputting base file
%%------------
\documentclass[a4paper]{article}
%\usepackage{camomile-record}
\usepackage[dvips]{color,graphicx}
\usepackage{times}
\usepackage{geometry}\geometry{hscale=0.8,vscale=0.7}
\usepackage{url}
\usepackage{decimal}
\usepackage{prtdrug2}
\usepackage{fancyhdr}


\begin{document}



%%===========header============================
\newcommand{\patientlabel}{%
       \framebox{\rule[-10mm]{0cm}{3.3cm}%
       \hspace{2.2cm}Patient label\hspace{2.2cm}}}

\noindent\hspace{10.1cm}\patientlabel

\vspace{-3.5cm}
\noindent\hspace{2.3cm}{\color{blue}\LARGE AN{\AE}STHESIA RECORD}

\vspace{3mm}
\noindent\hspace{5.2cm}\textsf{Nottingham City Hospital} %% 2.3cm

\noindent\hspace{5.0cm}\hspace{2.27cm}{\color{blue}\textsf{NHS Trust}}

%------
\vspace{2.2cm}%\vspace{4mm} 1.7
%\noindent\hspace{2mm}\vbox{%
%\begin{tabular}{|ll|}
%\hline
%{\sc Date:} \rule{0pt}{12pt}  &  \today  \\
%{\sc Operation:}   &   \hspace{5.5cm} \\
%{\sc Anaesthetists:}  & RWD Nickalls \textit{et al.}  \\
%{\sc Surgeons:}  &   \\
%\hline
%\end{tabular}
%}
%%================================
\pagestyle{fancy}
```

```
\fancyhead{}
\fancyfoot{}
\rhead{An{\ae}sthesia Record---Log File\hspace{1cm}\thepage}
 %\rhead{\thepage}
 \lfoot{\hrule\vspace{0.5\baselineskip}
\copyright\ RWD Nickalls, S Dales \& A Nice 1994--2004: {\sc an{\ae}sthesia record
system---camomile---}\textit{Linux}
{\newline}\textsc{email} \textit{dicknickalls@compuserve.com}
 }
%%================
 %%--------------------
 %% check location of the base.log file
\typeout{** getting the base.log file from parent dir}%
\input{baselognew.data}
%%------------------------

\end{document}
%%==========footnote=============================
```

16.4 printall.tex

```
#!/usr/bin/perl
### printALL.pl
## prints all the anes-nn.dvi and anes-drug.dvi files
##-----------------------------------------
#-w   ## turned off for the moment
##------------------
## do in reverse order with drug on top
if (-e "anes-10.dvi") {system("dvips anes-10.dvi")} else{};
if (-e "anes-09.dvi") {system("dvips anes-09.dvi")} else{};
if (-e "anes-08.dvi") {system("dvips anes-08.dvi")} else{};
if (-e "anes-07.dvi") {system("dvips anes-07.dvi")} else{};
if (-e "anes-06.dvi") {system("dvips anes-06.dvi")} else{};
if (-e "anes-05.dvi") {system("dvips anes-05.dvi")} else{};
if (-e "anes-04.dvi") {system("dvips anes-04.dvi")} else{};
if (-e "anes-03.dvi") {system("dvips anes-03.dvi")} else{};
if (-e "anes-02.dvi") {system("dvips anes-02.dvi")} else{};
if (-e "anes-01.dvi") {system("dvips anes-01.dvi")}
    else{print "no anes-nn.dvi files available\n"};
# print the drug sheet last (on top)
if (-e "anes-drug.dvi") {print "...printing file anes-drug.dvi\n";
                         system("dvips anes-drug.dvi")}
   else {print "no anes-drug.dvi file available\n"};
##-----------------------------------------------------
       __END__
```

Part V

Data processing—stand-alone printing module

Chapter 17

Printing—the stand-alone (SA) module

April 19, 2009 /allfiles/book-xenon/ch-printmod-sa.tex

17.1 Introduction

Although the automated 'in-line' printing module (described in chapter X) worked well in processing the data immediately at the end of an operation (by clicking on the 'print last case' button on the launcher widget), it was difficult to implement retrospectively—for example, when wanting to re-processing a different database of `.binlog` files (typically placed in the /`fields`/ subdirectory).

The /`pdata`/ sub-directory contains the original output of processed data. A typical directory structure of an operation database which, for example, started at 13:42 hrs on September 23, 2005, is as follows.

```
.../camomiletop/theatredata/2005-Sep-23-1342/
.../camomiletop/theatredata/2005-Sep-23-1342/fields/
.../camomiletop/theatredata/2005-Sep-23-1342/pdata/
```

A new 'stand-alone' printing module was therefore developed, which (a) was simpler (i.e. did not use Simon Dales' `camomilefields2tex` C-program, or need to read the `starttime.dat` file), and (b) could be pointed at a particular /`fields`/ subdirectory to generate the full printable anaesthesia record in the usual way. The output of all data processed by this SA module is stored in a separate /`PDATA`/ sub-directory (i.e. we preserve the original /`pdata`/ sub-directory) as follows.

```
.../camomiletop/theatredata/2005-Sep-23-1342/
.../camomiletop/theatredata/2005-Sep-23-1342/fields/
.../camomiletop/theatredata/2005-Sep-23-1342/pdata/
.../camomiletop/theatredata/2005-Sep-23-1342/PDATA/
```

The suite of Perl programs making up this 'stand-alone' module is coordinated by the Perl program
`processdata.pl`. All the programs and scripts required for processing and printing are stored in the

/.../camomiletop/datexsim/printfiles/ directory. The various programs are as follows.

```
processdata.pl     ... coordinates the module (in the ‘operation’ directory)
fields2PDATA.pl    ... main program in the \dir{PDATA} dir
binlog2gnn.pl      ... converts .binlog files to .gnn files
binlog2data.pl     ... converts .binlog files to .data files
prtanes6.tex       ... TeX file for typesetting the graphs
prtdrug2.sty       ... TeX style option required by  printdrug.tex
prtdrug.tex        ... TeX file for typesetting the drug page
base2texd.pl       ... ASCII to TeX conversion from keyboard entry log file
```

17.2 Running the processdata.pl script

To start the process we first need to move the Perl script processdata.pl into the appropriate operation directory (e.g., /2005-Sep-23-1423/); we then need to move to that directory and type the following at the commandline.

```
perl processdata.pl
```

In due course the script will be made to take the PATH of the operation directory as a parameter, in which case the user will type something like the following, from any location (or even within a script).

```
perl processdata.pl  .../camomiletop/theatredata/2005-Sep-23-1342
```

The key steps performed by this module are as folows (the relevant program/script is shown in a box):

- Create a sub-directory called /PDATA/ $\boxed{\text{processdata.pl}}$
- Move key files into the /PDATA/ sub-directory $\boxed{\text{processdata.pl}}$
- Determine the start-time of data collection $\boxed{\text{fields2PDATA.pl}}$
- Convert the Unix-time in .binlog files → local-time in .data files $\boxed{\text{binlog2data.pl}}$
- Split up the .data files into 1-hr .gnn files $\boxed{\text{binlog2gnn.pl}}$
- Convert the .gnn files into GNUplot scripts for plotting $\boxed{\text{binlog2gnn.pl}}$
- Run gnuplot to generate the separate graphs in LaTeX format
- Run LaTeX to typeset the graphs and keyboard entry log $\boxed{\text{*.tex}}$ as the anaesthetic record

We now address the printing process in some detail, covering the various steps from the raw .binlog files output by the Camomile data module to the production of the paper endpoint—the Anaesthetic Record—which is placed in the patient notes. The full code of the eight or so Perl programs is listed in the subsequent chapters.

a1 Create the log file and make new directory

```
#[processdata.pl]
use Carp;       ## better error messages
use File::Copy; ## for copying files
use Cwd;        ## for grabbing PATH of  current working directory
use FindBin;    ## gets name of perl script and  base dir
##---------------------
open (logfile, ">./processdata.log")||die "ERROR: can't open file <processdata.log>\n";
## get progName and its base dir
$name1=$FindBin::Bin;
$programname=$FindBin::Script;
      print (logfile "this LOG generated by program < ",$programname," > \n");
$timenow=localtime();
      print (logfile $timenow,"\n");
      print (logfile "Running program: ",$name1,"/", $programname,"\n");
$thisdir=cwd;  ## grab the PATH of current working dir
      print (logfile $thisdir,"\n");
## create the /PDATA/ dir
mkdir 'PDATA',0744; ## format = mkdir  dir, mode (black book p 283)
```

a2 Copy the required software tools to the /PDATA/ directory

We now copy a suite of files (required for data processing and printing) from the /datexsim/printfiles/ directory to the /PDATA/ directory. We use the secure copy command from the File::Copy module. Note that with this command we can only copy one file at a time. In the extract below, we copy the file fields2PDATA.pl.

```
#[processdata.pl]
...
## copy the required printTOOLS files from  /camomiletop/datexsim/printfiles/ to .../PDATA/
$fromdir="../../datexsim/printfiles/";
$file1="fields2PDATA.pl";
   copy ($fromdir.$file1 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file1,"]... file copied OK \n")}
        else {print (logfile "...[",$file1,"] *** COPY ERROR: ", $!,"\n")}
...
```

After copying all the files (currently six files) we then have everything in place for processing the data, so we now move to the /pdata/ directory in preparation for the next phase—data processing—and call the Perl coordinating program fields2PDATA.pl as follows.

```
#[processdata.pl]
...
$PDATAdir="PDATA";
chdir $PDATAdir;
```

b Data processing—launch program fields2PDATA.pl

The data processing is coordinated by the Perl script fields2PDATA.pl, so the next thing is (a) first check we are in the correct directory (/PDATA/), and if so, then to launch the program (using the `system()` command), writing appropriate comments to the logfile as we go.

```
#[processdata.pl]
...
## check we are in the correct directory
print (logfile "the current dir is: \n");
$thisdir=cwd; ## grab the current working dir
print (logfile $thisdir,"\n");
## now call fields2PDATA.pl
$perlprog="fields2PDATA.pl";
print (logfile  "CALLing program <",$perlprog,">");
if (-e $perlprog) {print "\n CALLing program ", $perlprog,"\n";
                   print (logfile  "... OK...done\n");
                   system("perl ./"."$perlprog")}
   else{print "...ERROR: can't find file <$perlprog>\n";
        print (logfile  " ** ERROR: can't find file <$perlprog>\n")};
```

c Determine the start-time

The first thing the `fields2PDATA.pl` script does is to determine the start-time by reading the time associated with the first data point in each of the `.binlog` files in the /`fields`/ directory, and selecting the earliest as defining the working start-time. Armed with a working start-time, we can then determine an ‘elapsed-time’ for each data-event. In practice these times are expressed as so-called Unix-time (seconds since 1st Jan 1970).

Each line of a typical `.binlog` file is a comma-separated data-pair, where the first item is the Unix time, and the second item is the parameter value. An example of a typical `sat.binlog` structure is as follows (`sat.binlog`).

```
## sat.binlog
1071580231,92
1071580236,92
1071580241,93
1071580246,93.5
1071580251,93
1071580256,93
1071580261,92.5
1071580266,92
...
...
```

The `fields2PDATA.pl` script starts by determining the earliest data entry time for each of the `.binlog` files, and then setting this earliest time as the `$starttimeunix` variable.

It does this by reading only the first Unix-time entry in each of the `.binlog` files (reading each filename from an array of all such filenames), and determining the earliest time. It also writes comments to the logfile so we can check its progress if we need to investigate any errors.

```
#[fields2PDATA.pl]
```

```
...
## make an array of all required input filenames
## we are running this from the /PDATA/ dir
 @fieldfilename = (
      "../fields/bp-d.binlog",
      "../fields/bp-s.binlog",
      "../fields/ecg-rr.binlog",
"../fields/co2-exp.binlog",
"../fields/co2-insp.binlog",
"../fields/co2-rr.binlog",
"../fields/cvp.binlog",
"../fields/ecg-hr.binlog",
"../fields/ecg-rr.binlog",
"../fields/mac-big.binlog",
"../fields/mac-n2o.binlog",
"../fields/mac-vap.binlog",
"../fields/mv-exp.binlog",
"../fields/n2o-exp.binlog",
"../fields/nibp-d.binlog",
"../fields/nibp-s.binlog",
"../fields/o2-insp.binlog",
"../fields/pplat.binlog",
"../fields/sat.binlog",
"../fields/sat-hr.binlog",
"../fields/temp[0].binlog",
"../fields/temp[1].binlog",
"../fields/tv-exp.binlog",
"../fields/tv-insp.binlog",
"../fields/vap-code.binlog",
"../fields/vap-exp.binlog",
"../fields/vap-insp.binlog"
       );
#get each .binlog file in turn, and read the first line for UNIXtime
 for ($j=0; $j<=$#fieldfilename; $j=$j+1 )
     {
      $ifile = $fieldfilename[$j];
      if (-e $ifile) {
          open (fieldsfile, "<$ifile")||die "ERROR: can't open file $ifile\n";
         }
         else {print (printlog $ifile, " does NOT exist\n");
              next}
      print "...reading the fields file <bp-d.binlog> to access UNIX time\n";
      $n=0; ## line counter
      LINE: while (<fieldsfile>){
          next LINE if /^#/;  #skip # comments
          next LINE if /^%/;  #skip % comments
         next LINE if /^$/;  #skip blank lines
          # grab the whole line as a string
      $dataline = $_;
      $n=$n+1; ## increment line counter
      chomp($dataline); # removes the line-ending
      ## print the line to the log file
      print (printlog $dataline,", filename = ", $ifile, "\n");
        #---------------------
          #print "the line is: $dataline\n";
          # place the two params into an array
          @value=split (/[,]/, $dataline);
         ## get no of items (should be only two items)
          $nitems= $#value +1;
         print "no of items in the line = $nitems\n";
          #---------------
      $time=$value[0];
      $parametervalue=$value[1];
      ## determine the least time (J = file counter)
      if ($j==1){$starttimeunix=$time}
         else {
               if ($time < $starttimeunix) {$starttimeunix = $time};
             };
      ## only require the first UNIXtime from this file
     if ($n==1){last}    #n is line counter
 }; # end of line loop
 }; #end of file loop
 close (fieldsfile);
 print (printlog "...finished reading all the .binlog files \n");
```

d Decode the Unix start-time → local-time

The start-time (in Unix-time) is required later by the subroutine makegnnfiles() in the script binlog2gnn.pl in order to be able to split up the .data files created by the script binlog2data.pl into one-page data files (files containing data which will be typeset on a single page of the Anaesthetic Record)[1]

We now decode the Unix start-time.

```
#[fields2PDATA.pl]
...
# $starttimeunix  has been determined above
     $starttimegmt= localtime($starttimeunix);
      $originalgmt=$starttimegmt; ## needed for  printing header on anaes sheet (below)
              print (printlog  "starttimeunix =$starttimeunix\n");
              print (printlog  "starttimegmt = $starttimegmt\n");
              print (printlog "--------------------------- \n");

    ## now put the starttimeGMT into an array
    #--------------------------------------------
    ## note the main items are <space> separated except hh:mm:ss
    ## format is:    Sun Jan 25 13:24:35 2004
    ## format is:    Sun Jan  5 13:24:35 2004
```

[1] Typically a page contains 1 hour of data (sampled at 45 second intervals), but it is useful to be able to devote single pages to a shorter period of time, in order to view the data in greater resolution—say, every 5 seconds, having only 6 minutes of data per page.

```
 ## note **** get /two/ spaces after the Month if days <10
 ## modified from SUB tedname() in launchcam12.pl
 ##-------------------------------------------
          # if two spaces in posn 8 and 9 then remove one
          if (substr($starttimegmt,7,2) eq "  ") {substr($starttimegmt,7,2," ")};
          ##print " tr string = $startgmtstring\n";
          ## replace spaces with commas
          $starttimegmt =~ tr/ /,/;
          ## make an array
          @stgmt=split (/[,]/, $starttimegmt);
          $day=$stgmt[0];
          $month=$stgmt[1];
          $date=$stgmt[2];
          $st=$stgmt[3];
          $year=$stgmt[4];
          $noitems=$#stgmt+1;
  print (printlog "....extracted starttimeUNIX [$starttimeunix]\n");
          print (printlog "....extracted starttimeGMT  [$starttimegmt]\n");
  print (printlog "....extracted no. of gmt items = $ngmtitems ($corr)\n");
  print (printlog "....extracted gmt part is: $day,$month,$date,$st,$year,$year2\n");
          print (printlog "....extracted starttime hh:mm:ss [$st]\n");
  print "starttime=$starttimegmt\n";
  print " no of gmt items = $ngmtitems\n";
          print "the gmt part is: $day,$month,$date,$st,$year\n";
  #--------------------
#####? need to include some error checking ie abort if probem with the times
 ######    goto LASTLINE; ## abort program
```

e Running the script binlog2gnn.pl

We now (a) convert each .binlog file into a .data file (see below), and then (b) each of these is split into a series of 1-page .gnn files, e.g,. g01, .g02, ... etc., (each typically representing 1-hour periods), such that the data of each .gnn file is destined to be typeset on a single page of the Anaesthetic Record.

```
# [fields2PDATA.pl]
...
system ("perl binlog2gnn.pl $starttimeunix");
```

f Convert .binlog files to .data files

The program binlog2gnn.pl first rewrites each .binlog file into a more useful and informative .data files, each line of which will then also include two extra data items, namely (a) a local-time translation of the Unix-time, and (b) the elapsed-time since the start of data collection (the start-time).

The script binlog2gnn.pl CALLs the binlog2data.pl script to perform this particular task.

```
# [binlog2gnn.pl]
...
```

```
#!/usr/bin/perl
$starttimeunix = $ARGV[0];  ## used by the SUB Makegnnfiles()
open (timefile, ">timefile.dat")||die "ERROR: can't open file timefile.dat\n";
##------------
# make an array of all required paremater names used for printing anaes Record
 @paramname = ("bp-s", "bp-d","ecg-hr","sat-hr","cvp","nibp-s","nibp-d",
               "sat", "o2-insp", "n2o-exp", "co2-exp",
              "tv-exp","co2-rr","pplat", "vap-insp", "vap-exp", "mac-big" );
 #get each parameter .binlog file in turn
 for ($j=0; $j<=$#paramname; $j=$j+1 )
     {
      $ifile = $paramname[$j]; ##  NO .binlog file-extension here
      system ("perl binlog2data.pl  $ifile") ;
...
     }
```

A typical example of the sat.data file is as follows. Note that the elapsed-time parameter on the first line is zero, and that both the unix-time and the elapsed-times increase in steps of 5 seconds (data is output from the Datex monitor every 5 seconds).

```
#[sat.data]
1071580231, 2003:12:16:13:10:31,  0, 92.000000
1071580236, 2003:12:16:13:10:36,  5, 92.000000
1071580241, 2003:12:16:13:10:41, 10, 93.000000
1071580246, 2003:12:16:13:10:46, 15, 93.500000
1071580251, 2003:12:16:13:10:51, 20, 93.000000
1071580256, 2003:12:16:13:10:56, 25, 93.000000
1071580261, 2003:12:16:13:11:1,  30, 92.500000
1071580266, 2003:12:16:13:11:6,  35, 92.000000
...
...
```

Armed with the above .data file for a given parameter, then we proceed to generate from this a series of 1-page .gnn files (each typically of 1-hour duration), as described in the next section.

g Generate 1-page .gnn files with subroutine makegnnfiles()

This role of this subroutine is to generate from the new parameter .data file (which may contain many hours of data, since it contains *all* the data held in the original .binlog file) a series of 1-page .gnn files suitable for use by the GNUplot graphing program—each .gnn file generating a single page of the typeset Anaesthetic Record.

The makegnnfiles() subroutine is part of the Perl program binlog2gnn.pl (which is itself called by the co-ordinating Perl program fields2PDATA.pl). The subroutine is called with the field parameter name (for example, bp-d, or sat-hr) as follows.

```
makegnnfiles($paramname[$j]);
```

Calling the subroutine makennnfiles() converts each of the parameter .data files into a series of 1-page duration two-column space-separated data-files suitable for accessing by gnuplot. For example, a 4-hr `sat.data` file would typically be be converted into four page-files (1-hour per page) as follows: `sat.g01, sat.g02, sat.g03, sat.g04` (generally known at the `.gnn` files).

The `makegnnfiles()` subroutine also generated an elapsed time for each data-point within each page-file relative to the beginning of each page (typically, each hour) by using the new computed "start-time" for each page-file as the zero-time, i.e. the elapsed time within a 1-hour `.gnn` file will run from 0—3599 secs (i.e. just 1 hour per page in this case). We have three ⟨space⟩ delimited fields namely ⟨elapsed-time-(local)⟩, ⟨parameter⟩, ⟨unix-time⟩.

The subroutine works out how to split up the `.data` file into 1-page chunks (of 1-page time periods) by using the difference between the operation start-time and the unix-time on each line of data. Note that the Unix start-time was passed to the `binlog2gnn.pl` program by the calling program (`fields2PDATA.pl`). If the elapsed time exceeds the page-duration (the default is 1-hour), then the current `.gnn` file is closed, and the next one opened etc.

In practice, however, the default sampling-interval is 45 second intervals (this interval can be easily varied depending on the graph-plotting/typesetting requirements). So although the original `.binlog` data accumulates every 5 seconds (from the Datex AS/3 monitor), the actual printed data is typically thinned out somewhat, purely because there is a limit to the density of data which can usefully be printed on the Anaesthesia Record. If better resolution is required, then higher resolution printing can be performed at a later date, by making both the sampling-interval and the page-duration shorter, for example, we could plot *all* the data by making the sampling-interval (from the `.data`-file) → 0 seconds, and having a page-duration of 6 minutes—that is by plotting 72 data-points (at 5-second intervals) per 6-minute page.

```
#[binlog2gnn.pl]
...
  sub makegnnfiles {
       ## get the starttimeUNIX  passed from commandline value --> @ARGV
       ## the starttimeUNIX is obtained originally from file <starttime.dat>
        $starttimeunix = $ARGV[0];
        # passing only one name into array
       my ($file) = @_;
       print "---processing parameter [$file] \n";
       # add the file-ending .dat
       $infilename=$file.".data"; ###*
       print "---the input filename is [$infilename] \n";
       open (infile, "<$infilename")||die "ERROR: can't find file $infilename \n";
       # now make time-dependent out filename
       # start with hour set to zero
       $hour=0;
       #---------------
       # start inputting lines of data
       #need to get the time associated with  line 1
       #
     $interval=45; #secs
     $oldelapsedtime=0;
    LINE: while (<infile>){
          next LINE if /^#/;  #skip comments
```

```
 next LINE if /^%/;  #skip comments
 next LINE if /^$/;  #skip blank lines
 # grab the whole line as a string
 $dataline = $_;
 # place the params into an array
 @value=split (/[,]/, $dataline);
 # print " $value[0]   $value[1]  $value[2]\n";
# assign the elapsedtime and param values
$unixtime=$value[0];
$gmtime=$value[1]; #GMT yyyy:mm:dd:hh::mm:ss
$elapsedtime = $value[2]; #elapsed-time (secs)
$paramvalue=$value[3];
chomp($paramvalue);  # remove the line-ending to help maths
#--------------------
# multiply the rr values by 50 (to make them fit range 0--1000)
if ($file eq "co2-rr"){$paramvalue=$paramvalue * 50};
#----------------
## save data only every $interval (secs)
$elapsedtime=$unixtime-$starttimeunix; ## determine true elapsedtime
if ($elapsedtime < $oldelapsedtime +$interval)
   {next LINE}
   else{$oldelapsedtime = $elapsedtime}

       #---------------
#now print data into 1 hr files
# make NewElapsed time relative to begining of new hour
# hour 1 = first real hour
# hour will be zero on first run thro algorithm so goes to  else...
if  ($elapsedtime <$hour *3600){
    $space="  ";
    # calculate new elapsed time from begining of new hour
    $newet=$elapsedtime-3600*($hour -1);
    print (outfile "$newet $space $paramvalue $space $unixtime\n");
       }
else{
    # close existing gnn file and open a new one (gnn+1)
    close (outfile);
    $hour=$hour + 1;
    #use two digits for the filename extension eg .g04
    if ($hour <10){$hour="0".$hour};
    $gnudatafilename=$file.".g".$hour;
    print "---the new output filename = $gnudatafilename \n";
    open (outfile,">$gnudatafilename")||die "can't open the outfile \n";
    # write some headers to the outfile
    $outfileheader1="## Camomile gnuplot datafilename = $gnudatafilename";
    $outfileheader2="## date?";
    print (outfile "$outfileheader1\n");
    print (outfile "$outfileheader2\n");
    # write  info to the timefile
    print (timefile "$hour, $unixtime, $gmtime, $gnudatafilename\n");
```

```
            $space=" ";
            # calculate new elapsed time from begining of new hour
            $newet=$elapsedtime-3600*($hour-1);
            print (outfile "$newet $space $paramvalue $space $unixtime\n");
            }#end of else{
       }#end o while
      close (infile);
      close (outfile);
 }#$
```

A typical example of a .gnn file (the file sat.g03) is as follows. There are three fields (elapsed-time, parameter-value, unix-time) which are space-separated. In this example the data was collected every 30-40 seconds or so and the elapsed-times are seen to be 31, 76, 121, ... etc. The unix-time field is retained as a check. The 03 in the filename extension .g03 indicates that it represents data collected during the third hour.

```
##[sat.g03]
31      87.500000    1080559619
76      88.000000    1080559664
121     89.500000    1080559709
166     93.000000    1080559754
211     94.500000    1080559799
256     95.000000    1080559844
301     95.000000    1080559889
346     95.000000    1080559934
391     95.000000    1080559979
436     94.500000    1080560024
...
...
```

g The log-file (timefile.txt)

Concurrently with the previous process, the program cam2gnnh.pl creates the timefile.dat file which holds the start-times for each of the .gnn files (see below). This file is very useful as a check on the functioning of the cam2gnnh.pl program.

```
#[timefile.txt]
...
...
01, 1071580301, 2003:12:16:13:11:41, bp-s.g01
02, 1071583865, 2003:12:16:14:11:5, bp-s.g02
03, 1071587465, 2003:12:16:15:11:5, bp-s.g03
...
...
01, 1071580276, 2003:12:16:13:11:16, sat.g01
02, 1071583840, 2003:12:16:14:10:40, sat.g02
03, 1071587440, 2003:12:16:15:10:40, sat.g03
...
...
```

h The base.log file (baselog.data)

After processing all the parameter fields → .gnn files we then access (extract) the anaesthetists log file (base.log) using the camomilefielf2tex utility as before, only this time using the .l switch and the -s tex option since we are wanting to access a log file.

```
#[cam2gnnh.pl]
...
system ("camomilefield2tex -p $projdir  -l base   -o baselog.data  -s tex") ;
```

Note that since we are running this command from within the /pdata/ subdirectory then the default location for the output files is the current directory.

17.3 Write the GNUplot scripts for each graph

Each 1-hour page of the Anaesthesia Record consists of six separate graphs, each showing a time plot of several parameters. Each spearate graph requires its own so called .gnu file (script) which sets up the graph structure and plots each parameter inside it. All this is coordinated by the Perl program plotgnnk2.pl, and so we will look in more detail how this is done.

Each parameter to be plotted has its own .gnn[2] parameter file (not absolutely necessary but very convenient in practice—see previous section). To facilitate this, we arrange that each 1-hour .gnn file has its elapsed time starting from zero, which greatly simplifies the plotting process.

The most difficult part of generating the .gnu files (one file per graph) is to construct the time-base, such that all .g01 parameter files are plotted on graphs showing the start and end times of the first hour, and also of the 15-minute vertical lines which are also drawn.

The timebase parameter $timeline

The time markings along the *x*-axis are drawn using the GNUplot set xtics() command which, in this case, takes a complicated parameter which is the string $timeline. In practice, for each hour the particular time-base used will be the same for all graphs drawn using parameters values from files having the same gnn value; say, .g02 files for example.

The following code determines this string for each hour, tailoring it to accomodate the time interval associated with each .gnn value, so as we move from one hour to the next then the time associated with each hour increases accordingly.

```
#[fields2PDATA.pl]
...
# determine the earliest start time from G01 files in timefile.dat file
# put the start-time-GMT[year:month:day:hrs:mins:sec] into an array
# then determine how many  hours worth of Gnn files there are
# $st is the start-time hh:mm:ss from the <starttime.dat> file (see above)
$JJ=gnnmax("01"); ## returns gnnMax
print (printlog "start-time = [$st] \n");
```

[2] Not to be confused with the .gnn data files.

```
print (printlog "GnnMax = $gnnmax \n");
# extract the separate hh, mm, ss values
@start_time= split (/[:]/, $st);
$starthour = $start_time[0];
$startminute=$start_time[1];
$startsecond=$start_time[2];
#------------
# now print all the graphs for all Gnn files from 01 to GnnMax
for ($gnn=1; $gnn<=$gnnmax; $gnn = $gnn+1)
    {
    # first determine time in secs to the begining of next full hour
    $deltah = 3600 - ($startminute*60 + $startsecond);
    # generate correct start-hour depending on Gnn value
    $h = $starthour + $gnn;
    $hminus1=$h-1;  $hplus1=$h+1;
    if ($h==0) {$hminus1=23};
    if ($h==23) {$hplus1=0};
    $q=900; $qq=1800; $qqq=2700; $qqqq=3600;
    # force 24hour clock
    if ($h <10){$h="0".$h};
    if ($hminus1 <10){$hminus1="0".$hminus1};
    if ($hplus1 <10){$hplus1="0".$hplus1};
    $deltahminusqqqq=$deltah-$qqqq;
    $deltahminusqqq=$deltah-$qqq;
    $deltahminusqq=$deltah-$qq;
    $deltahminusq=$deltah-$q;
    $deltahplusqqqq=$deltah+$qqqq;
    $deltahplusqqq=$deltah+$qqq;
    $deltahplusqq=$deltah+$qq;
    $deltahplusq=$deltah+$q;
    #---------------
    $t1 = "$hminus1.00"." $deltahminusqqqq";
    $t2 = "$hminus1.15"." $deltahminusqqq";
    $t3 = "$hminus1.30"." $deltahminusqq";
    $t4 = "$hminus1.45"." $deltahminusq";
    $t5 = "$h.00"." $deltah";
    $t6 = "$h.15"." $deltahplusq";
    $t7 = "$h.30"." $deltahplusqq";
    $t8 = "$h.45"." $deltahplusqqq";
    $t9 = "$hplus1.00"." $deltahplusqqqq";
    $timeline="$t1,$t2,$t3,$t4,$t5,$t6,$t7,$t8,$t9";
```

Armed with the time-base we can start making (write to) the .gnu files. In the following we illustrate the code for writing the sat.gnu script file (which will be processed by the GNUplot program eventually). First we check that the ‘hour’ value incorporated into the .gnn string always has two digits (i.e. 4 → 04 and hence we obtain g04), and defining the graph height to be used, we then open the output file and proceed.

```
#[fields2PDATA.pl]
...
```

```
# first make sure the gnn string has three characters
if ($gnn <10){$gnn="0".$gnn};
# define the graph heights
$smallheight=0.43; ## for all other graphs
...
...
## now create the sat file ------------------------
open(satfile, ">plot-sat.gnu")
              ||die "ERROR: can’t open  plot-sat.gnu file\n";
   print (satfile  "#!/usr/bin/gnuplot\n");
   print (satfile  "# plot-sat.gnu script made by plotgnnk2.pl\n");
   print (satfile  "set terminal latex\n");
   print (satfile  "set output \"plot-sat.pic\" \n");
   print (satfile  "set size 1.40,$smallheight\n");
   print (satfile  "set xtics($timeline)\n");
   print (satfile  "set ytics (\"\" 80,\"\" 90,\"\" 100)\n");
   print (satfile  "set y2tics (80, 90, 100)\n");
   print (satfile  "set nokey\n");
   print (satfile  "set grid\n");
   print (satfile  "xmin=0;xmax=3600\n");
   print (satfile  "ymin=80; ymax=100\n");
   print (satfile  "plot [xmin:xmax][ymin:ymax] \\\n");
   $satfilename="sat".".g".$gnn;
   $fo2filename="o2-insp".".g".$gnn;

   if (-e $satfilename)
        {print (satfile  "     \"$satfilename\" using 1:2 with linespoints 4  8,\\\n")}
        else {print (printlog " ---**** no sat.gnn files\n")};

   if (-e $fo2filename)
        {print (satfile  "     \"$fo2filename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no fo2.gnn files\n")};

   $dummyline = "      -20 with lines 1  # dummy line";
   print (satfile  "$dummyline \n");
   close (satfile);
```

It is significant here that in the last few lines of this code we have used the line

```
print (bpfile  "$dummyline \n");
```

This is to solve a problem which would arise should one or more of the parameter files not exist, as in this situation GNUplot graph plotting would fail since it requires that the final line must not have a comma at the end. By using a ‘dummy’ line (which has no comma and only plots a point below the graph (-20) and hence is never visibly plotted) as the final line, we are able to handle the failure of all or some of the parameter lines which therefore can all have a terminal comma.

17.4 Run GNUplot on all the .gnu files

Once all the .gnu files have been written, then we run GNUplot on each one to generate each figure in LaTeX 2$_\varepsilon$ picture format. Each printed sheet has five figures arranged horizontally from top to bottom. The legends are on the right hand side so they are not obscured by the binding when placed in the patient notes.

```
#[fields2PDATA.pl]
...
print (printlog "---running GNUPLOT on all the .gnu files\n");
system ("gnuplot plot-bp.gnu");
system ("gnuplot plot-sat.gnu");
system ("gnuplot plot-fo2.gnu");
system ("gnuplot plot-co2.gnu");
system ("gnuplot plot-tv.gnu");
system ("gnuplot plot-vap.gnu");
print (printlog "..........GNUPLOT ... done\n");
```

17.5 Write the header line for the printouts

Each printed sheet has a header indicating the start-time (GMT and unix) and the .dvi filename (which indicates which hour the sheet refers to) as follows:

```
Record start-time: Thu Feb 12 12:11:19 2004   unix 1076587879  anes-04.dvi
```

This is written to a file (header.dat) as follows, and then read back when needed for printing.

```
#[fields2PDATA.pl]
...
print "writing the <gnnheader.dat> file to contain header for Anes record   \n";
open (outfile5, ">gnnheader.dat")||die "ERROR: can't create file <gnnheader.dat>\n";
$timenow = localtime;
print (outfile5 "%% gnnheader.dat:  created  $timenow\n");
print (outfile5 "%% file generated by <plotgnnk2.pl> RWD Nickalls\n");
$fname="anes-".$gnn.".dvi";
print (outfile5 "\\header{$starttimeunix}{$originalgmt}{$fname}\n");
close (outfile5);
print "......<gnnheader.dat>.... done\n";
```

17.6 Typeset the graphic pages using LaTeX 2$_\varepsilon$

We now typeset the graph pages and create the output formats .dvi, .ps, and .pdf on the fly. The TeX file for the graphs is prtanes6.tex. The style option is prtdrug2.sty. We create the PostScript files using dvips. We create the .pdf files using pdflatex.

```
print (printlog "---running LATEX on prtanes6.tex\n");
system ("pslatex prtanes6.tex");
$dvifilename="anes-".$gnn.".dvi";
```

```
# copy the .dvi file to  have a gnn.dvi filename
system ("cp -v prtanes6.dvi $dvifilename");
# make the .ps files
$psfilename="anes-".$gnn.".ps";
system ("dvips $dvifilename -o $psfilename");
print (printlog "..........LATEX ...done\n");
# now make the pdf files
system ("pdflatex prtanes6.tex");
$pdffilename="anes-".$gnn.".pdf";
# copy the .pdf file to include a ..gnn.pdf filename
system ("cp -v prtanes6.pdf $pdffilename");
```

17.7 Typeset the drug file using LaTeX 2$_\varepsilon$

Processing the drug file (log file) is slightly more complicated owing to the fact that the typesetting is done using LaTeX 2$_\varepsilon$. Consequently, since the anaesthetists can enter data using the keyboard we need to filter out all non-TeX material (essentially to 'escape' certain ASCII characters; for example, we would modify % *rightarrow* \% etc). This conversion is currently done by the Perl program base2texd.pl, which processes the original log-file (baselog.data) to the 'filtered' file baselognew.data.

We now typeset the 'filtered' drug-file and create the output formats .dvi, .ps, and .pdf on the fly as before. The TeX file for the graphs is prtdrug.tex. The style option is prtdrug2.sty. We create the PostScript files using dvips. We create the .pdf files using pdflatex.

```
# process the baselog.data file
system ("perl ./base2texd.pl");
# now latex the prtdrug file
system ("latex ./prtdrug.tex");
# copy the .dvi file to  have a anes-drug.dvi filename
system ("cp -v prtdrug.dvi anes-drug.dvi");
# make the PS version of the .dvi file
system ("dvips anes-drug.dvi -o anes-drug.ps");
# make the pdf file
system ("pdflatex prtdrug.tex");
# copy the .pdf file to  have a gnn.pdf filename
system ("cp -v prtdrug.pdf anes-drug.pdf");
```

17.8 Printing the paper sheets

Finally, we print out all the sheets making up the Anaesthesia Record. This currently consists of one or more 'drug' sheets (the log file), together with a number of 1-hour graphic sheets presenting the measured parameters. These are usually printed out in the operating theatre and placed in the patient notes.

In practice a small Perl program (printall.pl) sends the final files to the printer in reverse order as follows.

```
#!/usr/bin/perl
```

```
# printALL.pl
# do graphs in reverse order
if (-e "anes-10.dvi") {system("dvips anes-10.dvi")} else{};
if (-e "anes-09.dvi") {system("dvips anes-09.dvi")} else{};
if (-e "anes-08.dvi") {system("dvips anes-08.dvi")} else{};
if (-e "anes-07.dvi") {system("dvips anes-07.dvi")} else{};
if (-e "anes-06.dvi") {system("dvips anes-06.dvi")} else{};
if (-e "anes-05.dvi") {system("dvips anes-05.dvi")} else{};
if (-e "anes-04.dvi") {system("dvips anes-04.dvi")} else{};
if (-e "anes-03.dvi") {system("dvips anes-03.dvi")} else{};
if (-e "anes-02.dvi") {system("dvips anes-02.dvi")} else{};
if (-e "anes-01.dvi") {system("dvips anes-01.dvi")} else{};
# print the drug sheet last (on top)
if (-e "anes-drug.dvi") {system("dvips anes-drug.dvi")} else {};
```

Chapter 18

Printing—the stand-alone (SA-06) module

April 19, 2009 /allfiles/book-xenon/ch-printmod-sa06.tex

18.1 Introduction

Although the automated 'in-line' printing module (described in chapter X) worked well in processing the data immediately at the end of an operation (by clicking on the 'print last case' button on the launcher widget), it was difficult to implement retrospectively—for example, when wanting to re-processing a different database of `.binlog` files (typically placed in the /`fields`/ subdirectory).

The /`pdata`/ sub-directory contains the original output of processed data. A typical directory structure of an operation database which, for example, started at 13:42 hrs on September 23, 2005, is as follows.

```
.../camomiletop/theatredata/2005-Sep-23-1342/
.../camomiletop/theatredata/2005-Sep-23-1342/fields/
.../camomiletop/theatredata/2005-Sep-23-1342/pdata/
```

A new 'stand-alone' printing module was therefore developed, which (a) was simpler (i.e. did not use Simon Dales' `camomilefields2tex` C-program, or need to read the `starttime.dat` file), and (b) could be pointed at a particular /`fields`/ subdirectory to generate the full printable anaesthesia record in the usual way. The output of all data processed by this SA module is stored in a separate /`PDATA`/ sub-directory (i.e. we preserve the original /`pdata`/ sub-directory) as follows.

```
.../camomiletop/theatredata/2005-Sep-23-1342/
.../camomiletop/theatredata/2005-Sep-23-1342/fields/
.../camomiletop/theatredata/2005-Sep-23-1342/pdata/
.../camomiletop/theatredata/2005-Sep-23-1342/PDATA/
```

The suite of Perl programs making up this 'stand-alone' module is coordinated by the Perl program
`processdata.pl`. All the programs and scripts required for processing and printing are stored in the

/.../camomiletop/datexsim/printfiles/ directory. The various programs are as follows.

```
processdata.pl     ... coordinates the module (in the ‘operation’ directory)
fields2PDATA.pl    ... main program in the \dir{PDATA} dir
binlog2gnn.pl      ... converts .binlog files to .gnn files
binlog2data.pl     ... converts .binlog files to .data files
prtanes6.tex       ... TeX file for typesetting the graphs
prtdrug2.sty       ... TeX style option required by  printdrug.tex
prtdrug.tex        ... TeX file for typesetting the drug page
base2texd.pl       ... ASCII to TeX conversion from keyboard entry log file
```

18.2 Running the processdata.pl script

To start the process we first need to move the Perl script processdata.pl into the appropriate operation directory (e.g., /2005-Sep-23-1423/); we then need to move to that directory and type the following at the commandline.

```
perl processdata.pl
```

In due course the script will be made to take the PATH of the operation directory as a parameter, in which case the user will type something like the following, from any location (or even within a script).

```
perl processdata.pl  .../camomiletop/theatredata/2005-Sep-23-1342
```

The key steps performed by this module are as folows (the relevant program/script is shown in a box):

- Create a sub-directory called /PDATA/ $\boxed{\text{processdata.pl}}$
- Move key files into the /PDATA/ sub-directory $\boxed{\text{processdata.pl}}$
- Determine the start-time of data collection $\boxed{\text{fields2PDATA.pl}}$
- Convert the Unix-time in .binlog files → local-time in .data files $\boxed{\text{binlog2data.pl}}$
- Split up the .data files into 1-hr .gnn files $\boxed{\text{binlog2gnn.pl}}$
- Convert the .gnn files into GNUplot scripts for plotting $\boxed{\text{binlog2gnn.pl}}$
- Run gnuplot to generate the separate graphs in LaTeX format
- Run LaTeX to typeset the graphs and keyboard entry log $\boxed{\text{*.tex}}$ as the anaesthetic record

We now address the printing process in some detail, covering the various steps from the raw .binlog files output by the Camomile data module to the production of the paper endpoint—the Anaesthetic Record—which is placed in the patient notes. The full code of the eight or so Perl programs is listed in the subsequent chapters.

a1 Create the log file and make new directory

```
#[processdata.pl]
use Carp;       ## better error messages
use File::Copy; ## for copying files
use Cwd;        ## for grabbing PATH of  current working directory
use FindBin;    ## gets name of perl script and  base dir
##----------------------
open (logfile, ">./processdata.log")||die "ERROR: can't open file <processdata.log>\n";
## get progName and its base dir
$name1=$FindBin::Bin;
$programname=$FindBin::Script;
      print (logfile "this LOG generated by program < ",$programname," > \n");
$timenow=localtime();
      print (logfile $timenow,"\n");
      print (logfile "Running program: ",$name1,"/", $programname,"\n");
$thisdir=cwd;  ## grab the PATH of current working dir
      print (logfile $thisdir,"\n");
## create the /PDATA/ dir
mkdir 'PDATA',0744; ## format = mkdir  dir, mode (black book p 283)
```

a2 Copy the required software tools to the /PDATA/ directory

We now copy a suite of files (required for data processing and printing) from the /datexsim/printfiles/ directory to the /PDATA/ directory. We use the secure copy command from the File::Copy module. Note that with this command we can only copy one file at a time. In the extract below, we copy the file fields2PDATA.pl.

```
#[processdata.pl]
...
## copy the required printTOOLS files from  /camomiletop/datexsim/printfiles/ to .../PDATA/
$fromdir="../../datexsim/printfiles/";
$file1="fields2PDATA.pl";
   copy ($fromdir.$file1 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file1,"]... file copied OK \n")}
        else {print (logfile "...[",$file1,"] *** COPY ERROR: ", $!,"\n")}
...
```

After copying all the files (currently six files) we then have everything in place for processing the data, so we now move to the /pdata/ directory in preparation for the next phase—data processing—and call the Perl coordinating program fields2PDATA.pl as follows.

```
#[processdata.pl]
...
$PDATAdir="PDATA";
chdir $PDATAdir;
```

b Data processing—launch program fields2PDATA.pl

The data processing is coordinated by the Perl script fields2PDATA.pl, so the next thing is (a) first check we are in the correct directory (/PDATA/), and if so, then to launch the program (using the system() command), writing appropriate comments to the logfile as we go.

```
#[processdata.pl]
...
## check we are in the correct directory
print (logfile "the current dir is: \n");
$thisdir=cwd; ## grab the current working dir
print (logfile $thisdir,"\n");
## now call fields2PDATA.pl
$perlprog="fields2PDATA.pl";
print (logfile  "CALLing program <",$perlprog,">");
if (-e $perlprog) {print "\n CALLing program ", $perlprog,"\n";
                   print (logfile  "... OK...done\n");
                   system("perl ./"."$perlprog")}
   else{print "...ERROR: can't find file <$perlprog>\n";
        print (logfile  " ** ERROR: can't find file <$perlprog>\n")};
```

c Determine the start-time

The first thing the fields2PDATA.pl script does is to determine the start-time by reading the time associated with the first data point in each of the .binlog files in the /fields/ directory, and selecting the earliest as defining the working start-time. Armed with a working start-time, we can then determine an 'elapsed-time' for each data-event. In practice these times are expressed as so-called Unix-time (seconds since 1st Jan 1970).

Each line of a typical .binlog file is a comma-separated data-pair, where the first item is the Unix time, and the second item is the parameter value. An example of a typical sat.binlog structure is as follows (sat.binlog).

```
## sat.binlog
1071580231,92
1071580236,92
1071580241,93
1071580246,93.5
1071580251,93
1071580256,93
1071580261,92.5
1071580266,92
...
...
```

The fields2PDATA.pl script starts by determining the earliest data entry time for each of the .binlog files, and then setting this earliest time as the $starttimeunix variable.

It does this by reading only the first Unix-time entry in each of the .binlog files (reading each filename from an array of all such filenames), and determining the earliest time. It also writes comments to the logfile so we can check its progress if we need to investigate any errors.

```
#[fields2PDATA.pl]
```

```
...
## make an array of all required input filenames
## we are running this from the /PDATA/ dir
 @fieldfilename = (
      "../fields/bp-d.binlog",
      "../fields/bp-s.binlog",
      "../fields/ecg-rr.binlog",
"../fields/co2-exp.binlog",
"../fields/co2-insp.binlog",
"../fields/co2-rr.binlog",
"../fields/cvp.binlog",
"../fields/ecg-hr.binlog",
"../fields/ecg-rr.binlog",
"../fields/mac-big.binlog",
"../fields/mac-n2o.binlog",
"../fields/mac-vap.binlog",
"../fields/mv-exp.binlog",
"../fields/n2o-exp.binlog",
"../fields/nibp-d.binlog",
"../fields/nibp-s.binlog",
"../fields/o2-insp.binlog",
"../fields/pplat.binlog",
"../fields/sat.binlog",
"../fields/sat-hr.binlog",
"../fields/temp[0].binlog",
"../fields/temp[1].binlog",
"../fields/tv-exp.binlog",
"../fields/tv-insp.binlog",
"../fields/vap-code.binlog",
"../fields/vap-exp.binlog",
"../fields/vap-insp.binlog"
       );
#get each .binlog file in turn, and read the first line for UNIXtime
 for ($j=0; $j<=$#fieldfilename; $j=$j+1 )
     {
      $ifile = $fieldfilename[$j];
      if (-e $ifile) {
          open (fieldsfile, "<$ifile")||die "ERROR: can't open file $ifile\n";
         }
         else {print (printlog $ifile, " does NOT exist\n");
              next}
      print "...reading the fields file <bp-d.binlog> to access UNIX time\n";
      $n=0; ## line counter
      LINE: while (<fieldsfile>){
          next LINE if /^#/;  #skip # comments
          next LINE if /^%/;  #skip % comments
         next LINE if /^$/;  #skip blank lines
          # grab the whole line as a string
      $dataline = $_;
      $n=$n+1; ## increment line counter
      chomp($dataline); # removes the line-ending
      ## print the line to the log file
      print (printlog $dataline,", filename = ", $ifile, "\n");
        #---------------------
          #print "the line is: $dataline\n";
          # place the two params into an array
          @value=split (/[,]/, $dataline);
         ## get no of items (should be only two items)
          $nitems= $#value +1;
         print "no of items in the line = $nitems\n";
          #---------------
      $time=$value[0];
      $parametervalue=$value[1];
      ## determine the least time (J = file counter)
      if ($j==1){$starttimeunix=$time}
         else {
               if ($time < $starttimeunix) {$starttimeunix = $time};
             };
      ## only require the first UNIXtime from this file
     if ($n==1){last}    #n is line counter
 }; # end of line loop
 }; #end of file loop
 close (fieldsfile);
 print (printlog "...finished reading all the .binlog files \n");
```

d Decode the Unix start-time → local-time

The start-time (in Unix-time) is required later by the subroutine makegnnfiles() in the script binlog2gnn.pl in order to be able to split up the .data files created by the script binlog2data.pl into one-page data files (files containing data which will be typeset on a single page of the Anaesthetic Record)[1]

We now decode the Unix start-time.

```
#[fields2PDATA.pl]
...
# $starttimeunix  has been determined above
     $starttimegmt= localtime($starttimeunix);
      $originalgmt=$starttimegmt; ## needed for  printing header on anaes sheet (below)
              print (printlog  "starttimeunix =$starttimeunix\n");
              print (printlog  "starttimegmt = $starttimegmt\n");
              print (printlog "--------------------------- \n");

    ## now put the starttimeGMT into an array
    #--------------------------------------------
    ## note the main items are <space> separated except hh:mm:ss
    ## format is:    Sun Jan 25 13:24:35 2004
    ## format is:    Sun Jan  5 13:24:35 2004
```

[1] Typically a page contains 1 hour of data (sampled at 45 second intervals), but it is useful to be able to devote single pages to a shorter period of time, in order to view the data in greater resolution—say, every 5 seconds, having only 6 minutes of data per page.

```
 ## note **** get /two/ spaces after the Month if days <10
 ## modified from SUB tedname() in launchcam12.pl
 ##-------------------------------------------
          # if two spaces in posn 8 and 9 then remove one
          if (substr($starttimegmt,7,2) eq "  ") {substr($starttimegmt,7,2," ")};
          ##print " tr string = $startgmtstring\n";
          ## replace spaces with commas
          $starttimegmt =~ tr/ /,/;
          ## make an array
          @stgmt=split (/[,]/, $starttimegmt);
          $day=$stgmt[0];
          $month=$stgmt[1];
          $date=$stgmt[2];
          $st=$stgmt[3];
          $year=$stgmt[4];
          $noitems=$#stgmt+1;
  print (printlog "....extracted starttimeUNIX [$starttimeunix]\n");
          print (printlog "....extracted starttimeGMT  [$starttimegmt]\n");
  print (printlog "....extracted no. of gmt items = $ngmtitems ($corr)\n");
  print (printlog "....extracted gmt part is: $day,$month,$date,$st,$year,$year2\n");
          print (printlog "....extracted starttime hh:mm:ss [$st]\n");
  print "starttime=$starttimegmt\n";
  print " no of gmt items = $ngmtitems\n";
          print "the gmt part is: $day,$month,$date,$st,$year\n";
  #--------------------
#####? need to include some error checking ie abort if probem with the times
 ######    goto LASTLINE; ## abort program
```

e Running the script binlog2gnn.pl

We now (a) convert each .binlog file into a .data file (see below), and then (b) each of these is split into a series of 1-page .gnn files, e.g,. g01, .g02, ... etc., (each typically representing 1-hour periods), such that the data of each .gnn file is destined to be typeset on a single page of the Anaesthetic Record.

```
# [fields2PDATA.pl]
...
system ("perl binlog2gnn.pl $starttimeunix");
```

f Convert .binlog files to .data files

The program binlog2gnn.pl first rewrites each .binlog file into a more useful and informative .data files, each line of which will then also include two extra data items, namely (a) a local-time translation of the Unix-time, and (b) the elapsed-time since the start of data collection (the start-time).

The script binlog2gnn.pl CALLs the binlog2data.pl script to perform this particular task.

```
# [binlog2gnn.pl]
...
```

```
#!/usr/bin/perl
$starttimeunix = $ARGV[0];  ## used by the SUB Makegnnfiles()
open (timefile, ">timefile.dat")||die "ERROR: can't open file timefile.dat\n";
##------------
# make an array of all required paremater names used for printing anaes Record
 @paramname = ("bp-s", "bp-d","ecg-hr","sat-hr","cvp","nibp-s","nibp-d",
               "sat", "o2-insp", "n2o-exp", "co2-exp",
              "tv-exp","co2-rr","pplat", "vap-insp", "vap-exp", "mac-big" );
 #get each parameter .binlog file in turn
 for ($j=0; $j<=$#paramname; $j=$j+1 )
     {
      $ifile = $paramname[$j]; ##  NO .binlog file-extension here
      system ("perl binlog2data.pl  $ifile") ;
...
     }
```

A typical example of the sat.data file is as follows. Note that the elapsed-time parameter on the first line is zero, and that both the unix-time and the elapsed-times increase in steps of 5 seconds (data is output from the Datex monitor every 5 seconds).

```
#[sat.data]
1071580231, 2003:12:16:13:10:31,  0, 92.000000
1071580236, 2003:12:16:13:10:36,  5, 92.000000
1071580241, 2003:12:16:13:10:41, 10, 93.000000
1071580246, 2003:12:16:13:10:46, 15, 93.500000
1071580251, 2003:12:16:13:10:51, 20, 93.000000
1071580256, 2003:12:16:13:10:56, 25, 93.000000
1071580261, 2003:12:16:13:11:1,  30, 92.500000
1071580266, 2003:12:16:13:11:6,  35, 92.000000
...
...
```

Armed with the above .data file for a given parameter, then we proceed to generate from this a series of 1-page .gnn files (each typically of 1-hour duration), as described in the next section.

g Generate 1-page .gnn files with subroutine makegnnfiles()

This role of this subroutine is to generate from the new parameter .data file (which may contain many hours of data, since it contains *all* the data held in the original .binlog file) a series of 1-page .gnn files suitable for use by the GNUplot graphing program—each .gnn file generating a single page of the typeset Anaesthetic Record.

The makegnnfiles() subroutine is part of the Perl program binlog2gnn.pl (which is itself called by the co-ordinating Perl program fields2PDATA.pl). The subroutine is called with the field parameter name (for example, bp-d, or sat-hr) as follows.

```
makegnnfiles($paramname[$j]);
```

Calling the subroutine makennnfiles() converts each of the parameter .data files into a series of 1-page duration two-column space-separated data-files suitable for accessing by gnuplot. For example, a 4-hr sat.data file would typically be be converted into four page-files (1-hour per page) as follows: sat.g01, sat.g02, sat.g03, sat.g04 (generally known at the .gnn files).

The makegnnfiles() subroutine also generated an elapsed time for each data-point within each page-file relative to the beginning of each page (typically, each hour) by using the new computed "start-time" for each page-file as the zero-time, i.e. the elapsed time within a 1-hour .gnn file will run from 0—3599 secs (i.e. just 1 hour per page in this case). We have three ⟨space⟩ delimited fields namely ⟨elapsed-time-(local)⟩, ⟨parameter⟩, ⟨unix-time⟩.

The subroutine works out how to split up the .data file into 1-page chunks (of 1-page time periods) by using the difference between the operation start-time and the unix-time on each line of data. Note that the Unix start-time was passed to the binlog2gnn.pl program by the calling program (fields2PDATA.pl). If the elapsed time exceeds the page-duration (the default is 1-hour), then the current .gnn file is closed, and the next one opened etc.

In practice, however, the default sampling-interval is 45 second intervals (this interval can be easily varied depending on the graph-plotting/typesetting requirements). So although the original .binlog data accumulates every 5 seconds (from the Datex AS/3 monitor), the actual printed data is typically thinned out somewhat, purely because there is a limit to the density of data which can usefully be printed on the Anaesthesia Record. If better resolution is required, then higher resolution printing can be performed at a later date, by making both the sampling-interval and the page-duration shorter, for example, we could plot *all* the data by making the sampling-interval (from the .data-file) → 0 seconds, and having a page-duration of 6 minutes—that is by plotting 72 data-points (at 5-second intervals) per 6-minute page.

```
#[binlog2gnn.pl]
...
  sub makegnnfiles {
       ## get the starttimeUNIX  passed from commandline value --> @ARGV
       ## the starttimeUNIX is obtained originally from file <starttime.dat>
        $starttimeunix = $ARGV[0];
        # passing only one name into array
       my ($file) = @_;
       print "---processing parameter [$file] \n";
       # add the file-ending .dat
       $infilename=$file.".data"; ###*
       print "---the input filename is [$infilename] \n";
       open (infile, "<$infilename")||die "ERROR: can't find file $infilename \n";
       # now make time-dependent out filename
       # start with hour set to zero
       $hour=0;
       #---------------
       # start inputting lines of data
       #need to get the time associated with  line 1
       #
     $interval=45; #secs
     $oldelapsedtime=0;
    LINE: while (<infile>){
          next LINE if /^#/;  #skip comments
```

```
 next LINE if /^%/;  #skip comments
 next LINE if /^$/;  #skip blank lines
 # grab the whole line as a string
 $dataline = $_;
 # place the params into an array
 @value=split (/[,]/, $dataline);
 # print " $value[0]   $value[1]  $value[2]\n";
# assign the elapsedtime and param values
$unixtime=$value[0];
$gmtime=$value[1]; #GMT yyyy:mm:dd:hh::mm:ss
$elapsedtime = $value[2]; #elapsed-time (secs)
$paramvalue=$value[3];
chomp($paramvalue);  # remove the line-ending to help maths
#--------------------
# multiply the rr values by 50 (to make them fit range 0--1000)
if ($file eq "co2-rr"){$paramvalue=$paramvalue * 50};
#----------------
## save data only every $interval (secs)
$elapsedtime=$unixtime-$starttimeunix; ## determine true elapsedtime
if ($elapsedtime < $oldelapsedtime +$interval)
   {next LINE}
   else{$oldelapsedtime = $elapsedtime}

       #---------------
#now print data into 1 hr files
# make NewElapsed time relative to begining of new hour
# hour 1 = first real hour
# hour will be zero on first run thro algorithm so goes to  else...
if  ($elapsedtime <$hour *3600){
    $space="  ";
    # calculate new elapsed time from begining of new hour
    $newet=$elapsedtime-3600*($hour -1);
    print (outfile "$newet $space $paramvalue $space $unixtime\n");
       }
else{
    # close existing gnn file and open a new one (gnn+1)
    close (outfile);
    $hour=$hour + 1;
    #use two digits for the filename extension eg .g04
    if ($hour <10){$hour="0".$hour};
    $gnudatafilename=$file.".g".$hour;
    print "---the new output filename = $gnudatafilename \n";
    open (outfile,">$gnudatafilename")||die "can’t open the outfile \n";
    # write some headers to the outfile
    $outfileheader1="## Camomile gnuplot datafilename = $gnudatafilename";
    $outfileheader2="## date?";
    print (outfile "$outfileheader1\n");
    print (outfile "$outfileheader2\n");
    # write  info to the timefile
    print (timefile "$hour, $unixtime, $gmtime, $gnudatafilename\n");
```

```
            $space=" ";
            # calculate new elapsed time from begining of new hour
            $newet=$elapsedtime-3600*($hour-1);
            print (outfile "$newet $space $paramvalue $space $unixtime\n");
            }#end of else{
       }#end o while
      close (infile);
      close (outfile);
 }#$
```

A typical example of a .gnn file (the file sat.g03) is as follows. There are three fields (elapsed-time, parameter-value, unix-time) which are space-separated. In this example the data was collected every 30-40 seconds or so and the elapsed-times are seen to be 31, 76, 121, ... etc. The unix-time field is retained as a check. The 03 in the filename extension .g03 indicates that it represents data collected during the third hour.

```
##[sat.g03]
31      87.500000    1080559619
76      88.000000    1080559664
121     89.500000    1080559709
166     93.000000    1080559754
211     94.500000    1080559799
256     95.000000    1080559844
301     95.000000    1080559889
346     95.000000    1080559934
391     95.000000    1080559979
436     94.500000    1080560024
...
...
```

g The log-file (timefile.txt)

Concurrently with the previous process, the program cam2gnnh.pl creates the timefile.dat file which holds the start-times for each of the .gnn files (see below). This file is very useful as a check on the functioning of the cam2gnnh.pl program.

```
#[timefile.txt]
...
...
01, 1071580301, 2003:12:16:13:11:41, bp-s.g01
02, 1071583865, 2003:12:16:14:11:5, bp-s.g02
03, 1071587465, 2003:12:16:15:11:5, bp-s.g03
...
...
01, 1071580276, 2003:12:16:13:11:16, sat.g01
02, 1071583840, 2003:12:16:14:10:40, sat.g02
03, 1071587440, 2003:12:16:15:10:40, sat.g03
...
...
```

h The base.log file (baselog.data)

After processing all the parameter fields → .gnn files we then access (extract) the anaesthetists log file (base.log) using the camomilefielf2tex utility as before, only this time using the .l switch and the -s tex option since we are wanting to access a log file.

```
#[cam2gnnh.pl]
...
system ("camomilefield2tex -p $projdir  -l base   -o baselog.data  -s tex") ;
```

Note that since we are running this command from within the /pdata/ subdirectory then the default location for the output files is the current directory.

18.3 Write the GNUplot scripts for each graph

Each 1-hour page of the Anaesthesia Record consists of six separate graphs, each showing a time plot of several parameters. Each spearate graph requires its own so called .gnu file (script) which sets up the graph structure and plots each parameter inside it. All this is coordinated by the Perl program plotgnnk2.pl, and so we will look in more detail how this is done.

Each parameter to be plotted has its own .gnn[2] parameter file (not absolutely necessary but very convenient in practice—see previous section). To facilitate this, we arrange that each 1-hour .gnn file has its elapsed time starting from zero, which greatly simplifies the plotting process.

The most difficult part of generating the .gnu files (one file per graph) is to construct the time-base, such that all .g01 parameter files are plotted on graphs showing the start and end times of the first hour, and also of the 15-minute vertical lines which are also drawn.

The timebase parameter $timeline

The time markings along the x-axis are drawn using the GNUplot set xtics() command which, in this case, takes a complicated parameter which is the string $timeline. In practice, for each hour the particular time-base used will be the same for all graphs drawn using parameters values from files having the same gnn value; say, .g02 files for example.

The following code determines this string for each hour, tailoring it to accomodate the time interval associated with each .gnn value, so as we move from one hour to the next then the time associated with each hour increases accordingly.

```
#[fields2PDATA.pl]
...
# determine the earliest start time from G01 files in timefile.dat file
# put the start-time-GMT[year:month:day:hrs:mins:sec] into an array
# then determine how many  hours worth of Gnn files there are
# $st is the start-time hh:mm:ss from the <starttime.dat> file (see above)
$JJ=gnnmax("01"); ## returns gnnMax
print (printlog "start-time = [$st] \n");
```

[2] Not to be confused with the .gnn data files.

```
print (printlog "GnnMax = $gnnmax \n");
# extract the separate hh, mm, ss values
@start_time= split (/[:]/, $st);
$starthour = $start_time[0];
$startminute=$start_time[1];
$startsecond=$start_time[2];
#------------

## ? make an array to hold the starttimes  of each gnn file
## these parameters are also used in binlog2GNN.pl to define the page size
## and sampling interval (from the .data files)
$pageseconds=440; ## = 88 x 5secs = no of seconds per typeset page
$interval=2; ## the sampling interval

##=================================================
# now print all the graphs for all Gnn files from 01 to GnnMax
for ($gnn=1; $gnn<=$gnnmax; $gnn = $gnn+1)
    {
   print (printlog "=======================================================\n");
   print (printlog "-----starting FOR/NEXT loop with Gnn = $gnn (gnnMax = $gnnmax)\n");
   ## the xtics() line is different for each Gnn


##---------------------------------------
## now write the timeline (xtics) string  for GNUplot
## work with unix time (seconds)
$gnnstartunix= $starttimeunix + ($gnn -1)*$pageseconds;
## SUB colonformattime() format=2004:9:23:13:40:29
$gnnstarttime=colonformattime($gnnstartunix);
## make an array
#  @mytime($tyear, $tmonth, $tday, $thour, $tmin, $tsec)=split (/[:]/, $gnncolonstarttime);
    @mytime=split (/[:]/, $gnnstarttime);
    $thour=$mytime[3];
    $tmin =$mytime[4];
    $tsec =$mytime[5];
##============================
## note that the output from colonFormattedTime is hrs and mins are two digits
## so do not need to add extra zero if <10 etc initially, but only if later
## determine the timeSecs ($ts) of the minute lines

$h=$thour;
$m=$tmin + 1; ## add 1 as the first minute mark is the /next/ full  minute
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     ## force leading zero of <10
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=60-$tsec;
     $t1=qq("$h:$m")." $ts";  ## GNUplot xtics format = ,timestring<space>x-value(secs),
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t2=qq("$h:$m")." $ts";
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t3=qq("$h:$m")." $ts";
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t4=qq("$h:$m")." $ts";
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t5=qq("$h:$m")." $ts";
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t6=qq("$h:$m")." $ts";
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t7=qq("$h:$m")." $ts";
$m=$m+1;
     if ($m > 59) {$m = $m%60; $h=$h + 1; if ($h>23){$h = $h%24}};
     $m= substr("00".$m, -2); $h= substr("00".$h, -2);
     $ts=$ts+60;
     $t8=qq("$h:$m")." $ts";

#-------------
  $timeline="$t1,$t2,$t3,$t4,$t5,$t6,$t7,$t8";
  print (printlog "set xtics($timeline)\n");
#=================================================
```

Armed with the time-base we can start making (write to) the .gnu files. In the following we illustrate the code for writing the sat.gnu script file (which will be processed by the GNUplot program eventually). First we check that the 'hour' value incorporated into the .gnn string always has two digits (i.e. 4 → 04 and hence we obtain g04), and defining the graph height to be used, we then open the output file and proceed.

```
#[fields2PDATA.pl]
...
```

```
# first make sure the gnn string has three characters
if ($gnn <10){$gnn="0".$gnn};
# define the graph heights
$smallheight=0.43; ## for all other graphs
...
...
## now create the sat file ------------------------
open(satfile, ">plot-sat.gnu")
              ||die "ERROR: can’t open  plot-sat.gnu file\n";
   print (satfile  "#!/usr/bin/gnuplot\n");
   print (satfile  "# plot-sat.gnu script made by plotgnnk2.pl\n");
   print (satfile  "set terminal latex\n");
   print (satfile  "set output \"plot-sat.pic\" \n");
   print (satfile  "set size 1.40,$smallheight\n");
   print (satfile  "set xtics($timeline)\n");
   print (satfile  "set ytics (\"\" 80,\"\" 90,\"\" 100)\n");
   print (satfile  "set y2tics (80, 90, 100)\n");
   print (satfile  "set nokey\n");
   print (satfile  "set grid\n");
   print (satfile  "xmin=0;xmax=3600\n");
   print (satfile  "ymin=80; ymax=100\n");
   print (satfile  "plot [xmin:xmax][ymin:ymax] \\\n");
   $satfilename="sat".".g".$gnn;
   $fo2filename="o2-insp".".g".$gnn;

   if (-e $satfilename)
        {print (satfile  "     \"$satfilename\" using 1:2 with linespoints 4  8,\\\n")}
        else {print (printlog " ---**** no sat.gnn files\n")};

   if (-e $fo2filename)
        {print (satfile  "     \"$fo2filename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no fo2.gnn files\n")};

   $dummyline = "      -20 with lines 1  # dummy line";
   print (satfile  "$dummyline \n");
   close (satfile);
```

It is significant here that in the last few lines of this code we have used the line

```
print (bpfile  "$dummyline \n");
```

This is to solve a problem which would arise should one or more of the parameter files not exist, as in this situation GNUplot graph plotting would fail since it requires that the final line must not have a comma at the end. By using a ‘dummy’ line (which has no comma and only plots a point below the graph (-20) and hence is never visibly plotted) as the final line, we are able to handle the failure of all or some of the parameter lines which therefore can all have a terminal comma.

18.4 Run GNUplot on all the .gnu files

Once all the .gnu files have been written, then we run GNUplot on each one to generate each figure in LaTeX 2ε picture format. Each printed sheet has five figures arranged horizontally from top to bottom. The legends are on the right hand side so they are not obscured by the binding when placed in the patient notes.

```
#[fields2PDATA.pl]
...
print (printlog "---running GNUPLOT on all the .gnu files\n");
system ("gnuplot plot-bp.gnu");
system ("gnuplot plot-sat.gnu");
system ("gnuplot plot-fo2.gnu");
system ("gnuplot plot-co2.gnu");
system ("gnuplot plot-tv.gnu");
system ("gnuplot plot-vap.gnu");
print (printlog "..........GNUPLOT ... done\n");
```

18.5 Write the header line for the printouts

Each printed sheet has a header indicating the start-time (GMT and unix) and the .dvi filename (which indicates which hour the sheet refers to) as follows:

```
Record start-time: Thu Feb 12 12:11:19 2004   unix 1076587879  anes-04.dvi
```

This is written to a file (header.dat) as follows, and then read back when needed for printing.

```
#[fields2PDATA.pl]
...
print "writing the <gnnheader.dat> file to contain header for Anes record   \n";
open (outfile5, ">gnnheader.dat")||die "ERROR: can't create file <gnnheader.dat>\n";
$timenow = localtime;
print (outfile5 "%% gnnheader.dat:  created  $timenow\n");
print (outfile5 "%% file generated by <plotgnnk2.pl> RWD Nickalls\n");
$fname="anes-".$gnn.".dvi";
print (outfile5 "\\header{$starttimeunix}{$originalgmt}{$fname}\n");
close (outfile5);
print "......<gnnheader.dat>.... done\n";
```

18.6 Typeset the graphic pages using LaTeX 2ε

We now typeset the graph pages and create the output formats .dvi, .ps, and .pdf on the fly. The TeX file for the graphs is prtanes6.tex. The style option is prtdrug2.sty. We create the PostScript files using dvips. We create the .pdf files using pdflatex.

```
print (printlog "---running LATEX on prtanes6.tex\n");
system ("pslatex prtanes6.tex");
$dvifilename="anes-".$gnn.".dvi";
```

```
# copy the .dvi file to  have a gnn.dvi filename
system ("cp -v prtanes6.dvi $dvifilename");
# make the .ps files
$psfilename="anes-".$gnn.".ps";
system ("dvips $dvifilename -o $psfilename");
print (printlog "..........LATEX ...done\n");
# now make the pdf files
system ("pdflatex prtanes6.tex");
$pdffilename="anes-".$gnn.".pdf";
# copy the .pdf file to include a ..gnn.pdf filename
system ("cp -v prtanes6.pdf $pdffilename");
```

18.7 Typeset the drug file using LaTeX 2ε

Processing the drug file (log file) is slightly more complicated owing to the fact that the typesetting is done using LaTeX 2ε. Consequently, since the anaesthetists can enter data using the keyboard we need to filter out all non-TeX material (essentially to 'escape' certain ASCII characters; for example, we would modify $\% \, rightarrow \, \backslash\%$ etc). This conversion is currently done by the Perl program base2texd.pl, which processes the original log-file (baselog.data) to the 'filtered' file baselognew.data.

We now typeset the 'filtered' drug-file and create the output formats .dvi, .ps, and .pdf on the fly as before. The TeX file for the graphs is prtdrug.tex. The style option is prtdrug2.sty. We create the PostScript files using dvips. We create the .pdf files using pdflatex.

```
# process the baselog.data file
system ("perl ./base2texd.pl");
# now latex the prtdrug file
system ("latex ./prtdrug.tex");
# copy the .dvi file to  have a anes-drug.dvi filename
system ("cp -v prtdrug.dvi anes-drug.dvi");
# make the PS version of the .dvi file
system ("dvips anes-drug.dvi -o anes-drug.ps");
# make the pdf file
system ("pdflatex prtdrug.tex");
# copy the .pdf file to  have a gnn.pdf filename
system ("cp -v prtdrug.pdf anes-drug.pdf");
```

18.8 Printing the paper sheets

Finally, we print out all the sheets making up the Anaesthesia Record. This currently consists of one or more 'drug' sheets (the log file), together with a number of 1-hour graphic sheets presenting the measured parameters. These are usually printed out in the operating theatre and placed in the patient notes.

In practice a small Perl program (printall.pl) sends the final files to the printer in reverse order as follows.

```
#!/usr/bin/perl
```

```
# printALL.pl
# do graphs in reverse order
if (-e "anes-10.dvi") {system("dvips anes-10.dvi")} else{};
if (-e "anes-09.dvi") {system("dvips anes-09.dvi")} else{};
if (-e "anes-08.dvi") {system("dvips anes-08.dvi")} else{};
if (-e "anes-07.dvi") {system("dvips anes-07.dvi")} else{};
if (-e "anes-06.dvi") {system("dvips anes-06.dvi")} else{};
if (-e "anes-05.dvi") {system("dvips anes-05.dvi")} else{};
if (-e "anes-04.dvi") {system("dvips anes-04.dvi")} else{};
if (-e "anes-03.dvi") {system("dvips anes-03.dvi")} else{};
if (-e "anes-02.dvi") {system("dvips anes-02.dvi")} else{};
if (-e "anes-01.dvi") {system("dvips anes-01.dvi")} else{};
# print the drug sheet last (on top)
if (-e "anes-drug.dvi") {system("dvips anes-drug.dvi")} else {};
```

Chapter 19

processdata.pl

April 19, 2009 /allfiles/book-xenon/ch-processdata.tex

```
#!/usr/bin/perl -w
## processdata.pl
## RWD Nickalls Oct 30, 2005
##-------------------------------
use Carp;       ## better error messages
use File::Copy; ## for copying files
use Cwd;        ## for grabbing current directory name
use FindBin;    ## gets name of perl program

##  processdata.pl
## RWD Nickalls
##
## a module for coordinating the processing of all fields data to /PDATA/
## and which DOES /NOT/ USE Simon Dales' camomilefiles2tex program.
## this module runs from the time-encoded dir itself.
## and processes all the Field files to final anes charts without needing to
## use the <starttime.dat. file (since the prog <fields2PDATA.pl> reads all
## the binlog files to determine the earliest start time).
## This program creates the /PCOPY/ subdir, copies across the necessary printfiles,
## and then  CALLS the program (fields2PDATA.pl)
##---------WARNING------------------------
## (1)  remember to change the path of the /printfiles/ when using in theatre
## (2) need to delete part which copies this prog back to /printfiles/ etc
##---------------------------------------
## processdata.pl (from  printlast.pl)
## October 16, 2005
## to process all the data - as a standalone file
##==================
## 1) read the starttime.dat if it exists, else read all the fields files to
## get earliest UNIX time

##===============================
      open (logfile, ">./processdata.log")||die "ERROR: can’t open file <processdata.log>\n";

$line="------------------------------------------";
## get progName and its base dir
$name1=$FindBin::Bin;
$programname=$FindBin::Script;
      print (logfile "this LOG generated by program < ",$programname," > \n");
$timenow=localtime();
      print (logfile $timenow,"\n");
      print (logfile "Running program: ",$name1,"/", $programname,"\n");
      print (logfile $line,"\n");
##==========================

##--------get this starting directory----------
print (logfile "the current (starting) dir is: \n");
system("pwd");
$thisdir=cwd;
print (logfile $thisdir,"\n");
#----------------------------------
##========================================================================================
print (logfile $line,"\n");

## create the /PDATA/ dir
## make it /PDATA/ to be different to show that processed via different route
## create new directory

#==========*************========
## copy this file back to /printfiles/ for safe keeping
## remember to delete this when finished testing
#copy ("processdata.pl", "../../datexsim/printfiles");
#=====================


print  (logfile "creating ./PDATA directory\n");
 # system ("mkdir PDATA");
mkdir ’PDATA’,0744; ## format = mkdir  dir, mode (black book p 283)
## now check the dir

print (logfile $line,"\n"); ##=================================

##===========copy printTOOLS files===================
## copy all printTOOLS files from /datexsim/printfiles/ to /PDATA/

print (logfile  "copying all required printfiles from  /datexsim/printfiles/  to  /PDATA/ \n");
$fromdir="../../datexsim/printfiles/";

$file1="fields2PDATA.pl";
```

```
   copy ($fromdir.$file1 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file1,"]... file copied OK \n")}
        else {print (logfile "...[",$file1,"] *** COPY ERROR: ", $!,"\n")}

$file2="binlog2gnn.pl"; ##(uses Dick's  binlog2data.pl)
   copy ($fromdir.$file2 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file2,"]... file copied OK \n")}
          else {print (logfile "...[",$file2,"] *** COPY ERROR: ", $!,"\n")}

$file21="binlog2data.pl"; ## CALLed by cam2gnnH2
   copy ($fromdir.$file21 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file21,"]... file copied OK \n")}
        else {print (logfile "...[",$file21,"] *** COPY ERROR: ", $!,"\n")}


$file3="prtanes6.tex";
   copy ($fromdir.$file3 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file3,"]... file copied OK \n")}
        else {print (logfile "...[",$file3,"] *** COPY ERROR: ", $!,"\n")}


$file4="prtdrug.tex";
   copy ($fromdir.$file4 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file4,"]... file copied OK \n")}
        else {print (logfile "...[",$file4,"] *** COPY ERROR: ", $!,"\n")}

$file5="prtdrug2.sty";
   copy ($fromdir.$file5 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file5,"]... file copied OK \n")}
        else {print (logfile "...[",$file5,"] *** COPY ERROR: ", $!,"\n")}

$file6="base2texd.pl";
## converts base.log/baselog.data --> something which TeX can print
   copy($fromdir.$file6 , "./PDATA");
   if ($! eq "") {print (logfile  "...[",$file6,"]... file copied OK \n")}
        else {print (logfile "...[",$file6,"] *** COPY ERROR: ", $!,"\n")}

print (logfile $line,"\n"); ##=======================
##============================================================================

## move to the required dir
print (logfile  "changing DIR to  /PDATA/ dir\n");
$PDATAdir="PDATA";
chdir $PDATAdir;
##note that   chdir is a PERL command (but cd is a Linux BASH command)
## now check we are in the correct directory
print (logfile "the current dir is: \n");
system("pwd"); ## writes to screen
$thisdir=cwd;
print (logfile $thisdir,"\n");
```

```
#----------------------------------
print (logfile $line,"\n"); ##===========================
##=======================================================
## now we can start crunching the Field files
## now call fields2PDATA.pl
$perlprog="fields2PDATA.pl";
print (logfile  "CALLing program <",$perlprog,">");
if (-e $perlprog) {print "\n CALLing program ", $perlprog,"\n";
                   print (logfile  "... OK...done\n");
                   system("perl ./"."$perlprog")}
   else{print "...ERROR: can't find file <$perlprog>\n";
        print (logfile  " ** ERROR: can't find file <$perlprog>\n")};
print (logfile $line,"\n"); ##==============================
##==========================================================
## return to orig directory
print "...returning to original directory\n";
print (logfile  "returning to original DIR\n");
chdir "..";
## check the dir
print (logfile "the current dir is: \n");
system("pwd"); ## writes to screen
$thisdir=cwd;
print (logfile $thisdir,"\n");
print (logfile $line,"\n");##============================
##========================================================
close (logfile);
 __END__
```

Chapter 20

fields2PDATA.pl

April 19, 2009 /allfiles/book-xenon/ch-fields2PDATA.tex

```
#!/usr/bin/perl
## fields2PDATA.pl
## -w   ## turned off for the moment
##------------------
# /camomiletop/datexsim/printfiles/fields2PDATA.pl (orig from plotgnnK2.pl)
# for gnuplot graphs with right-side y2labels
# prog for plotting Gnn files from .binlog files/cam2
# Dick Nickalls
# October 16,2005

#============================
## reminder
## remember to use latest version of files:
## cam2gnnH.pl
## plotgnnK2.pl
## prtanes6.tex
## base2tex.pl
## prt.drug2.sty
## prtdrug.tex
##======new changes=======================
## Feb 25 2004
## plot pplateau pressure = pplat.binlog
## also plot rr on fo2 graph as well to catch rr >20
#=============================
# this prog is run from within the /projdir/PDATA/ dir
##============================
# create a printer-log file
  open(printlog, ">printlog.txt")||die "ERROR: can't open printlog.txt file\n";
  ##
  $gmt = localtime();
  print (printlog "printlog.txt,  ",$gmt,"\n");
  print (printlog "log of the printing module [fields2PDATA.pl]\n");
  print (printlog "...this program is CALLed by < processdata.pl >\n");
  print (printlog "----------start of [perl fields2PDATA.pl]-----------\n");

##===============determine the UNIXstarttime from binlog files========================

## make an array of all required input filenames
## we are running this from the /PDATA/ dir

 @fieldfilename = (
      "../fields/bp-d.binlog",
      "../fields/bp-s.binlog",
      "../fields/ecg-rr.binlog",
"../fields/co2-exp.binlog",
"../fields/co2-insp.binlog",
"../fields/co2-rr.binlog",
"../fields/cvp.binlog",
"../fields/ecg-hr.binlog",
"../fields/ecg-rr.binlog",
"../fields/mac-big.binlog",
"../fields/mac-n2o.binlog",
"../fields/mac-vap.binlog",
"../fields/mv-exp.binlog",
"../fields/n2o-exp.binlog",
"../fields/nibp-d.binlog",
"../fields/nibp-s.binlog",
"../fields/o2-insp.binlog",
"../fields/pplat.binlog",
"../fields/sat.binlog",
"../fields/sat-hr.binlog",
"../fields/temp[0].binlog",
"../fields/temp[1].binlog",
"../fields/tv-exp.binlog",
"../fields/tv-insp.binlog",
"../fields/vap-code.binlog",
"../fields/vap-exp.binlog",
"../fields/vap-insp.binlog"
       );

 #get each .binlog file in turn, and read the first line for UNIXtime
 for ($j=0; $j<=$#fieldfilename; $j=$j+1 )
     {
      $ifile = $fieldfilename[$j];
      if (-e $ifile) {
          open (fieldsfile, "<$ifile")||die "ERROR: can't open file $ifile\n";
         }
         else {print (printlog $ifile, " does NOT exist\n");
              next}
      print "...reading the fields file <bp-d.binlog> to access UNIX time\n";
      $n=0; ## counter
      LINE: while (<fieldsfile>){
          next LINE if /^#/;  #skip # comments
          next LINE if /^%/;  #skip % comments
         next LINE if /^$/;  #skip blank lines
          # grab the whole line as a string
      $dataline = $_;
      $n=$n+1; ## increment counter
      chomp($dataline); # removes the line-ending
      ## print the line to the log file
      print (printlog $dataline,", filename = ", $ifile, "\n");

          #print "the line is: $dataline\n";
          # place the two params into an array
          @value=split (/[,]/, $dataline);
         ## get no of items (should be only two items)
          $nitems= $#value +1;
         print "no of items in the line = $nitems\n";
          #---------------
      $time=$value[0];
      $parametervalue=$value[1];
      ## determine the least time (J = file counter)
      if ($j==1){$starttimeunix=$time}
         else {
               if ($time < $starttimeunix) {$starttimeunix = $time};
             };
      ## only require the first UNIXtime from this file
     if ($n==1){last}    #n is line counter
 }; # end of line loop
 }; #end of file loop
 close (fieldsfile);

    print (printlog "...finished reading all the .binlog files \n");
##======================

             #$starttimeunix  has been determned above
             $starttimegmt= localtime($starttimeunix);
      $originalgmt=$starttimegmt; ## needed for  printing header on anaes sheet (below)
              print (printlog  "starttimeunix =$starttimeunix\n");
              print (printlog  "starttimegmt = $starttimegmt\n");
              print (printlog "-------------------------- \n");

            ## now put the starttimeGMT into an array
    #--------------------------------------------
    ## note the main items are <space> separated except hh:mm:ss
    ## format is:    Sun Jan 25 13:24:35 2004
    ## format is:    Sun Jan  5 13:24:35 2004
    ## note **** get /two/ spaces after the Month if days <10
    ## see SUB tedname() in launchcam12.pl
    ##-------------------------------------------
             # if two spaces in posn 8 and 9 then remove one
             if (substr($starttimegmt,7,2) eq "  ") {substr($starttimegmt,7,2," ")};
             ##print " tr string = $startgmtstring\n";
             ## replace spaces with commas
             $starttimegmt =~ tr/ /,/;
             ## make an array
             @stgmt=split (/[,]/, $starttimegmt);
             $day=$stgmt[0];
             $month=$stgmt[1];
             $date=$stgmt[2];
             $st=$stgmt[3];
             $year=$stgmt[4];
             $noitems=$#stgmt+1;
             print (printlog "....extracted starttimeUNIX [$starttimeunix]\n");
             print (printlog "....extracted starttimeGMT  [$starttimegmt]\n");
             print (printlog "....extracted no. of gmt items = $ngmtitems ($corr)\n");
             print (printlog "....extracted gmt part is: $day,$month,$date,$st,$year,$year2\n");
             print (printlog "....extracted starttime hh:mm:ss [$st]\n");
             print "starttime=$starttimegmt\n";
             print " no of gmt items = $ngmtitems\n";
             print "the gmt part is: $day,$month,$date,$st,$year\n";
     #--------------------
           #####? need to include some error checking ie abort if probem with the times
    ######    goto LASTLINE; ## abort program


#=============================
# now run cam2gnnH.pl to process all the X.binlog files --> X.data files
      print (printlog "running command [perl cam2gnnH.pl $starttimeunix  $projdir]\n");
      ## we pass both $starttimeunix and the path $projdir as well to <cam2gnnh>
      ## but these are needed only by Simon's
 ##************
  ###system ("perl cam2gnnH2.pl $starttimeunix  $projdir");
 system ("perl binlog2gnn.pl $starttimeunix");
      print (printlog ".......OK\n");
      print (printlog "======================================================\n");
#---------------------------------

##==================== PLOTTING/PRINTING ========================================

  ##(A) now establish the x-axis (time scale) = xtics string need start-time
  ## determine the earliest start time from G01 files in timefile.dat file
  # put the start-time-GMT[year:month:day:hrs:mins:sec] into an array
  ##(B) determine how many  hours worth of Gnn files there are
  $JJ=gnnmax("01"); ## returns gnnMax
      print (printlog "======================================================\n");
      print (printlog "start-time = [$st] \n");
      print (printlog "GnnMax = $gnnmax \n");
  ## $st is the start-time hh:mm:ss from the <starttime.dat> file (see above)
  ## extract the separate hh, mm, ss values
  @start_time= split (/[:]/, $st);
  $starthour = $start_time[0];
  $startminute=$start_time[1];
  $startsecond=$start_time[2];
  print (printlog "graphs: extracted start hour/min/sec are [$starthour, $startminute, $startsecon
#================================================
# now print all the graphs for all Gnn files from 01 to GnnMax
for ($gnn=1; $gnn<=$gnnmax; $gnn = $gnn+1)
    {
   print (printlog "=======================================================\n");
   print (printlog "-----starting FOR/NEXT loop with Gnn = $gnn (gnnMax = $gnnmax)\n");
   ## the xtics() line is different for each Gnn
   #print "$starthour,$startminute, $startsecond \n";
  # determine time in secs to the begining of next full hour
  $deltah = 3600 - ($startminute*60 + $startsecond);
       print (printlog "deltah = $deltah\n");
  # generate correct start-hour depending on Gnn value
  $h = $starthour + $gnn;
  $hminus1=$h-1;  $hplus1=$h+1;
  if ($h==0) {$hminus1=23};
  if ($h==23) {$hplus1=0};
  $q=900; $qq=1800; $qqq=2700; $qqqq=3600;
  # force 24hour clock
  if ($h <10){$h="0".$h};
  if ($hminus1 <10){$hminus1="0".$hminus1};
  if ($hplus1 <10){$hplus1="0".$hplus1};
  $deltahminusqqqq=$deltah-$qqqq;
  $deltahminusqqq=$deltah-$qqq;
  $deltahminusqq=$deltah-$qq;
  $deltahminusq=$deltah-$q;
  $deltahplusqqqq=$deltah+$qqqq;
  $deltahplusqqq=$deltah+$qqq;
  $deltahplusqq=$deltah+$qq;
  $deltahplusq=$deltah+$q;
  #---------------
  $t1 = qq("$hminus1.00")." $deltahminusqqqq";
  $t2 = qq("$hminus1.15")." $deltahminusqqq";
  $t3 = qq("$hminus1.30")." $deltahminusqq";
  $t4 = qq("$hminus1.45")." $deltahminusq";
  $t5 = qq("$h.00")." $deltah";
  $t6 = qq("$h.15")." $deltahplusq";
  $t7 = qq("$h.30")." $deltahplusqq";
  $t8 = qq("$h.45")." $deltahplusqqq";
  $t9 = qq("$hplus1.00")." $deltahplusqqqq";
  $timeline="$t1,$t2,$t3,$t4,$t5,$t6,$t7,$t8,$t9";
  print (printlog "set xtics($timeline)\n");


print (printlog "---starting to write all the .gnn files\n");
```

```
## first make sure the gnn string has three characters
if ($gnn <10){$gnn="0".$gnn};
#-------------------------------------
  ## define the graph heights
  $bigheight=0.9; ## for bp graph
  $smallheight=0.43; ## for all other graphs
#---------------------------------------
#=================
  ## now create the BP file
  open(bpfile, ">plot-bp.gnu")||die "ERROR: can’t open  plot-bp.gnu file\n";
     print (bpfile  "#!/usr/bin/gnuplot\n");
     print (bpfile  "# plot-bp.gnu script made by plotgnnk2.pl\n");
        print (bpfile  "set terminal latex\n");
        print (bpfile  "set output \"plot-bp.pic\" \n");
        print (bpfile "# NB full size = 5x3 inches; set x,y\n");
        print (bpfile   "set size 1.40,$bigheight\n");
     print (bpfile  "set xtics($timeline)\n");
     print (bpfile  "set noytics\n");
     print (bpfile  "set y2tics (0, 20, 50, 100, 150, 200)\n");
     # print (bpfile  "set y2label......");
 #print (satfile  "set y2label \’Sat \$\\circ\$\\\\ \\\\  FIO\$_2\$ \$\\bullet\$  \’ 1\n");
     print (bpfile  "set nokey\n");
     print (bpfile  "set grid\n");
     print (bpfile  "xmin=0;xmax=3600\n");
     print (bpfile  "ymin=0; ymax=200\n");
     print (bpfile  "plot [xmin:xmax][ymin:ymax] \\\n");
     print (bpfile  "     20 with lines 1,\\\n");
     print (bpfile  "     50 with lines 1,\\\n");
     print (bpfile  "     100 with lines 1,\\\n");
     print (bpfile  "     150 with lines 1,\\\n");
     $bpsfilename="bp-s".".g".$gnn;
     $bpdfilename="bp-d".".g".$gnn;

     $nibpsfilename="nibp-s".".g".$gnn;
     $nibpdfilename="nibp-d".".g".$gnn;

     $hrecgfilename="ecg-hr".".g".$gnn;
     $hroximfilename="sat-hr".".g".$gnn;
     $cvpfilename="cvp".".g".$gnn;

     if (-e $bpsfilename)
        {print (bpfile  "     \"$bpsfilename\" using 1:2 with linespoints 1  9,\\\n")}
        else {print (printlog " ---**** no bp-s.gnn files\n")};

     if (-e $bpdfilename)
        {print (bpfile  "     \"$bpdfilename\" using 1:2 with linespoints 1  8,\\\n")}
        else {print (printlog " ---**** no bp-d.gnn files\n")};
#--------------------------------
if (-e $nibpsfilename)
        {print (bpfile  "     \"$nibpsfilename\" using 1:2 with linespoints 1  3,\\\n")}
        else {print (printlog " ---**** no nibp-s.gnn files\n")};

     if (-e $nibpdfilename)
        {print (bpfile  "     \"$nibpdfilename\" using 1:2 with linespoints 1  3,\\\n")}
        else {print (printlog " ---**** no nibp-d.gnn files\n")};
#-----------------------------
     if (-e $hrecgfilename)
        {print (bpfile  "     \"$hrecgfilename\" using 1:2 with points 1  10,\\\n")}
        else {print (printlog " ---**** no hr-ecg.gnn files\n")};

     if (-e $hroximfilename)
         {print (bpfile  "     \"$hroximfilename\" using 1:2 with linespoints 1  10,\\\n")}
         else {print (printlog " ---**** no hr-oxim.gnn files\n")};

     if (-e $cvpfilename)
         {print (bpfile  "     \"$cvpfilename\" using 1:2 with lines 1,\\\n")}
         else{print (printlog " ---**** no cvp.gnn files\n")};
    ## need to use a dummyline to allow the graph frame to appear even if no data points,
    ## and so allow the last line to have a comma if the following line gets ommitted
    ## so we make the dummyline have no final comma
    ## we do this by drawing a line below the graph-- ie it does not appear
    $dummyline = "      -20 with lines 1  # dummy line";
          print (bpfile  "$dummyline \n");

    close (bpfile);
  print (printlog "---BP.gnu ....done\n");
  #=====================================================

  ## now create the sat file -------------------------
  open(satfile, ">plot-sat.gnu")||die "ERROR: can't open  plot-sat.gnu file\n";
     print (satfile  "#!/usr/bin/gnuplot\n");
     print (satfile  "# plot-sat.gnu script made by plotgnnk2.pl\n");
        print (satfile  "set terminal latex\n");
        print (satfile  "set output \"plot-sat.pic\" \n");
        print (satfile   "set size 1.40,$smallheight\n");
     print (satfile  "set xtics($timeline)\n");
     print (satfile  "set ytics (\"\" 80,\"\" 90,\"\" 100)\n");
     print (satfile  "set y2tics (80, 90, 100)\n");
     #$y2label = qq("\%\\\\Sat \$\\circ\$\\\\FIO\$_2\$ \$\\bullet\$");
   # print (satfile  "set y2label \'Sat \$\\circ\$\\\\ \\\\  FIO\$_2\$ \$\\bullet\$  \' 1\n");
     print (satfile  "set nokey\n");
     print (satfile  "set grid\n");
     print (satfile  "xmin=0;xmax=3600\n");
     print (satfile  "ymin=80; ymax=100\n");
     print (satfile  "plot [xmin:xmax][ymin:ymax] \\\n");
     $satfilename="sat".".g".$gnn;
     $fo2filename="o2-insp".".g".$gnn;


     if (-e $satfilename)
```

```
        {print (satfile  "     \"$satfilename\" using 1:2 with linespoints 4  8,\\\n")}
        else {print (printlog " ---**** no sat.gnn files\n")};

     if (-e $fo2filename)
        {print (satfile  "     \"$fo2filename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no fo2.gnn files\n")};



     print (satfile  "$dummyline \n");
     close (satfile);
  print (printlog "---SAT.gnu ....done\n");
  #====================================================



  ## now create the FO2 file (FIO2 + N2O) -------------------------
  open(fo2file, ">plot-fo2.gnu")||die "ERROR: can't open  plot-fo2.gnu file\n";
     print (fo2file  "#!/usr/bin/gnuplot\n");
     print (fo2file  "# plot-fo2.gnu script made by plotg01a.pl\n");
        print (fo2file  "set terminal latex\n");
        print (fo2file  "set output \"plot-fo2.pic\" \n");
        print (fo2file   "set size 1.388,$smallheight\n");  #was 1.4
     print (fo2file  "set xtics($timeline)\n");
     print (fo2file  "set noytics\n");
     print (fo2file  "set y2tics (10, 30, 50, 70)\n");
     #print (satfile  "set ytics (\"\" 10,\"\" 30,\"\" 50,\"\" 70)\n");
    # $ylabel = qq("\%\\\\Sat \$\\circ\$\\\\FIO\$_2\$ \$\\bullet\$");
    #print (fo2file  "set y2label \"hello\\\\ hello \"\n");
     print (fo2file  "set nokey\n");
     print (fo2file  "set grid\n");
     print (fo2file  "xmin=0;xmax=3600\n");
     print (fo2file  "ymin=10; ymax=70\n");
     print (fo2file  "plot [xmin:xmax][ymin:ymax] \\\n");
     print (fo2file  "     30 with lines 1,\\\n");
     print (fo2file  "     50 with lines 1,\\\n");
     $fo2filename="o2-insp".".g".$gnn;
     $n2ofilename="n2o-exp".".g".$gnn;
 $pplatfilename="pplat".".g".$gnn;

     if ( -e $fo2filename)
        {print (fo2file  "     \"$fo2filename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no fo2.gnn files\n")};

     if (-e $n2ofilename)
            {print (fo2file  "     \"$n2ofilename\" using 1:2 with linespoints 4  3,\\\n")}
            else {print (printlog " ---**** no n2o.gnn files\n")};

## using diamonds (as for MAC)
  if (-e $pplatfilename)
```

```
      {print (fo2file "     \"$pplatfilename\" using 1:2 with linespoints 4  8,\\\n")}
      else {print (printlog " ---**** no pplat.gnn files\n")};


   print (fo2file  "$dummyline \n");
close (fo2file);
print (printlog "---FO2.gnu ....done\n");
#===================================================

## now create the CO2 file  -------------------------
open(co2file, ">plot-co2.gnu")||die "ERROR: can’t open  plot-co2.gnu file\n";
   print (co2file  "#!/usr/bin/gnuplot\n");
   print (co2file  "# plot-co2.gnu script made by plotg01a.pl\n");
      print (co2file  "set terminal latex\n");
      print (co2file  "set output \"plot-co2.pic\" \n");
      print (co2file   "set size 1.387,$smallheight\n");  #was 1.4
   print (co2file  "set xtics($timeline)\n");
   print (co2file  "set noytics\n");
   print (co2file  "set y2tics (2, 4, 6, 8, 10)\n");
  # $ylabel = qq("\%\\\\Sat \$\\circ\$\\\\FIO\$_2\$ \$\\bullet\$");
  #print (co2file  "set y2label \"hello\\\\ hello \"\n");
   print (co2file  "set nokey\n");
   print (co2file  "set grid\n");
   print (co2file  "xmin=0;xmax=3600\n");
   print (co2file  "ymin=2; ymax=10\n");
   print (co2file  "plot [xmin:xmax][ymin:ymax] \\\n");
   print (co2file  "     4 with lines 1,\\\n");
   print (co2file  "     6 with lines 1,\\\n");
   print (co2file  "     8 with lines 1,\\\n");
   $co2expfilename="co2-exp".".g".$gnn;
   $rrfilename="co2-rr".".g".$gnn; ##plot rr here also


   if (-e $co2expfilename)
      {print (co2file  "     \"$co2expfilename\" using 1:2 with linespoints 4  1,\\\n")}
      else {print (printlog " ---**** no  co2-exp.gnn files\n")};

   ## we also plot the rr here to catch values >20
   if (-e $rrfilename)
       {print (co2file  "     \"$rrfilename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no  rr.gnn files\n")};


   print (co2file  "$dummyline \n");
 close (co2file);
print (printlog "---CO2.gnu ....done\n");
#===================================================

## now create the TV file (tv + rr)  -------------------------
open(tvfile, ">plot-tv.gnu")||die "ERROR: can’t open  plot-tv.gnu file\n";
```

```
   print (tvfile  "#!/usr/bin/gnuplot\n");
   print (tvfile  "# plot-tv.gnu script made by plotg01a.pl\n");
      print (tvfile  "set terminal latex\n");
      print (tvfile  "set output \"plot-tv.pic\" \n");
      print (tvfile   "set size 1.415,$smallheight\n");
   print (tvfile  "set xtics($timeline)\n");
   print (tvfile  "set noytics\n");
   print (tvfile  "set y2tics (0, 250, 500, 750, 1000)\n");
  # $y2label = qq("\%\\\\Sat \$\\circ\$\\\\FIO\$_2\$ \$\\bullet\$");
  #print (tvfile  "set y2label \"hello\\\\ hello \"\n");
   print (tvfile  "set nokey\n");
   print (tvfile  "set grid\n");
   print (tvfile  "xmin=0;xmax=3600\n");
   print (tvfile  "ymin=0; ymax=1000\n");
   print (tvfile  "plot [xmin:xmax][ymin:ymax] \\\n");
   print (tvfile  "     250 with lines 1,\\\n");
   print (tvfile  "     500 with lines 1,\\\n");
   print (tvfile  "     750 with lines 1,\\\n");
   $tvexpfilename="tv-exp".".g".$gnn;
   $rrfilename="co2-rr".".g".$gnn;

   if (-e $tvexpfilename)
      {print (tvfile  "     \"$tvexpfilename\" using 1:2 with linespoints 4  3,\\\n")}
      else {print (printlog " ---**** no  tv-exp.gnn files\n")};

   if (-e $rrfilename)
       {print (tvfile  "     \"$rrfilename\" using 1:2 with linespoints 4  10,\\\n")}
        else {print (printlog " ---**** no  rr.gnn files\n")};

   print (tvfile  "$dummyline \n");
   close (tvfile);
print (printlog "---TV.gnu ....done\n");
#===================================================


## now create the Vap file (vapIN, vapOUT, MAC)  ------------------------
open(vapfile, ">plot-vap.gnu")||die "ERROR: can’t open  plot-vap.gnu file\n";
   print (vapfile  "#!/usr/bin/gnuplot\n");
   print (vapfile  "# plot-vap.gnu script made by plotg01a.pl\n");
      print (vapfile  "set terminal latex\n");
      print (vapfile  "set output \"plot-vap.pic\" \n");
      print (vapfile   "set size 1.376,$smallheight\n");
   print (vapfile  "set xtics($timeline)\n");
   print (vapfile  "set noytics\n");
   print (vapfile  "set y2tics (0, 1, 2, 3, 4)\n");
  # $y2label = qq("\%\\\\Sat \$\\circ\$\\\\FIO\$_2\$ \$\\bullet\$");
  #print (vapfile  "set y2label \"hello\\\\ hello \"\n");
   print (vapfile  "set nokey\n");
   print (vapfile  "set grid\n");
   print (vapfile  "xmin=0;xmax=3600\n");
```

```
     print (vapfile  "ymin=0; ymax=4\n");
     print (vapfile  "plot [xmin:xmax][ymin:ymax] \\\n");
     print (vapfile  "     1 with lines 1,\\\n");
     print (vapfile  "     2 with lines 1,\\\n");
     print (vapfile  "     3 with lines 1,\\\n");
     $vapexpfilename="vap-exp".".g".$gnn;
     $vapinspfilename="vap-insp".".g".$gnn;
     $macbigfilename="mac-big".".g".$gnn;

     if (-e $vapexpfilename)
        {print (vapfile  "     \"$vapexpfilename\" using 1:2 with lines 1,\\\n")}
        else {print (printlog " ---**** no  vap-exp.gnn files\n")};

     if (-e $vapinspfilename)
        {print (vapfile  "     \"$vapinspfilename\" using 1:2 with lines 2,\\\n")}
        else {print (printlog " ---**** no  vap-insp.gnn files\n")};

     if (-e $macbigfilename)
         {print (vapfile  "     \"$macbigfilename\" using 1:2 with points 4 1,\\\n")}
         else {print (printlog " ---**** no  mac-big.gnn files\n")};

     print (vapfile  "$dummyline \n");
   close (vapfile);
  print (printlog "---VAP.gnu ....done\n");
  #=================================================

  # now run GNUplot on the .GNU files
  print (printlog "---running GNUPLOT on all the .gnu files\n");
      system ("gnuplot plot-bp.gnu");
      system ("gnuplot plot-sat.gnu");
      system ("gnuplot plot-fo2.gnu");
      system ("gnuplot plot-co2.gnu");
      system ("gnuplot plot-tv.gnu");
      system ("gnuplot plot-vap.gnu");
  print (printlog "..........GNUPLOT ... done\n");

  ##===============gnnheader.dat  file=============================

print "writing the <gnnheader.dat> file to contain header for Anes record   \n";


  open (outfile5, ">gnnheader.dat")||die "ERROR: can't create file <gnnheader.dat>\n";
  ##
  $timenow = localtime;
  print (outfile5 "%% gnnheader.dat:  created  $timenow\n");
  print (outfile5 "%% file generated by <plotgnnk2.pl> RWD Nickalls\n");
  $fname="anes-".$gnn.".dvi";
  print (outfile5 "\\header{$starttimeunix}{$originalgmt}{$fname}\n");
  ## note that here originalgmt = starttimegmt
  close (outfile5);
  print "......<gnnheader.dat>.... done\n";



  ##=============================================
#-----------
 print (printlog "---running LATEX on prtanes6.tex\n");
      system ("pslatex prtanes6.tex"); ### use pslatex
      $dvifilename="anes-".$gnn.".dvi";
      ## copy the .dvi file to  have a gnn.dvi filename
      system ("cp -v prtanes6.dvi $dvifilename");
     ##make the .ps files
      $psfilename="anes-".$gnn.".ps";
     system ("dvips $dvifilename -o $psfilename");
 print (printlog "...........LATEX ...done\n");
 ##----make the pdf files---
     system ("pdflatex prtanes6.tex"); ### use pslatex
      $pdffilename="anes-".$gnn.".pdf";
      ## copy the .pdf file to  have a gnn.pdf filename
      system ("cp -v prtanes6.pdf $pdffilename");
 ##------------------
## view the output graphs
 ##     system ("gv $psfilename");

    ##------------------


    ## show the .dvi file on the screen
     #  system ("xdvi $dvifilename");
    ## now send file to the printer
     #  system ("dvips $dvifilename");
    ######  goto OUTLINE;  ##***************
    ##---------------
    ## print the .dvi file to printer
     # system ("dvips prtanes6.dvi");


##--------------------------------------------------
} # end of the FOR()



##======process the prtdrug stuff=========================
   ####
   ###  process the baselog.data file
 system ("perl ./base2texd.pl");                   ##***************
    ## now latex the prtdrug file
 system ("latex ./prtdrug.tex");                   ##***************
#### copy the .dvi file to  have a anes-drug.dvi filename
      system ("cp -v prtdrug.dvi anes-drug.dvi"); ##************
```

```
#####
      #### make the PS version of the .dvi file to printer
     system ("dvips anes-drug.dvi -o anes-drug.ps");   ##***************

 ##----make the pdf file---
     system ("pdflatex prtdrug.tex");
      ## copy the .pdf file to  have a gnn.pdf filename
      system ("cp -v prtdrug.pdf anes-drug.pdf");
 ##------------------

## view the output .ps graphs
   ##   system ("gv anes-drug.ps");
##print out
  #    system ("dvips anes-drug.dvi");



close(printlog);



LASTLINE:;
OUTLINE:;
close;
##=======================SUBS========================

sub gnnmax{
      ## returns total number of hours (gnnMax)
      ##   by scanning the file <timefile.dat>
      ## the <timefile.dat> file is made by
      ## the SUB makegnnfiles() in prog cam2gnnH.pl
      $gnnmax=0;
      ## open the file for input
      open (timefile, "<timefile.dat")||die "ERROR: can't open file timefile.dat\n";
      #---------------
      LINE: while (<timefile>){
          next LINE if /^#/;  #skip # comments
          next LINE if /^%/;  #skip % comments
          next LINE if /^$/;  #skip blank lines
          # grab the whole line as a string
          # hour, unixtime, gmtime, gnnfilename
          $dataline = $_;
          chomp($dataline); # removes the line-ending
          print (printlog "[SUB start_time] dataline string (timefile.dat) = $dataline\n");
          # place the params into an array
          @value=split (/[,]/, $dataline);
          $hour=$value[0];
          $time_unix=$value[1];
          $time_gmt=$value[2]; #GMT yyyy:mm:dd:hh::mm:ss
          $gfile = $value[3];
          # get the largest Gnn value (gnnmax)
          if ($hour >= $gnnmax) {$gnnmax=$hour};
       } # end of while{
       close (timefile);
       print (printlog "[SUB start_time] GnnMax = $gnnmax\n");
       return $gnnmax;
     } #end of sub
#
##=================================
    __END__

   ==========================================
```