Abstract
A development approach for modern computer-based measurement systems is presented using an example. The pros and cons in using certain standard products to be incorporated are discussed. Some of the techniques (database, graphical representation of data, digital maps) are presented.

Introduction
During the last decade the company became a developer of standard and customer tailored measurement systems. By that time the company manufactured almost exclusively measurement devices.

The kind of customer tailored measurement systems discussed here give a good example of the use of modern software development techniques and the applicability of new standards and trends. The principal reasons for this are:
- the development underlies industrial constraints: cost, time and techniques; at the end the customer has to accept the product;
- systems are a mixture of hard and soft real time constraints;
- the development effort is high enough so that the project/software management is not trivial;
- systems are still small enough to be understood with reasonable effort;
- the development may start from scratch since no older products (HW/SW) have to be taken into account.

Task and Structure of a typical system
The measurement application described here is a typical frequency monitoring system in the VHF/UHF-range supplying a telecommunication authority with the necessary information for frequency management. Its aim is to:
- determine the occupancy of communication frequencies;
- measure the technical parameters of licensed transceivers;
- detect unlicensed transceivers.

It has the following main functions as shown in the SA-diagram.
The software development started with decisions on the implementation of some of the building blocks of the system. How successful this was can be seen looking at some of the techniques chosen for the implementation.

Additionally, we should use standard products wherever feasible to evaluate standard products in the early phases of the project. This consisted in the implementation of some of the building blocks of the system. How successful this was can be seen looking at some of the techniques chosen for the implementation.

Management, Analysis, Supervision and Interception are realized by manned working positions. Observation and Locating are background programs, Search and Supervision are background programs.

The central monitoring station (CMS) controls the remote monitoring stations (RMS), connected to the CMS via serial lines with data transfer rate of 4800/9600 baud. The measurement devices, located in the RMSs, consist of:

- Fast scanning receiver with up to 100 datasets/second;
- Direction finder with up to 2 datasets/second;
- Monitoring receiver with 1 dataset per operator command.

As a standard the DoD-STD-2167A was chosen. The philosophy taken as a basis was:

"Build on standard products to achieve portable standard blocks under an attractive user interface". This means in more detail:

- We should not develop a standard system but standard blocks which are easily adaptable and configurable, since most of these measurement systems are tailored to the customer's requirements;
- We should use standard products wherever feasible instead of developing new software, in order to keep the costs low;
- We should tie up the function blocks by means of a uniform and user friendly interface;
- We should develop the software in such a manner that it can be ported to other computer systems with minor effort.

A prototyping approach according to this philosophy followed to evaluate standard products in the early phases of the project. This consisted in the implementation of some of the building blocks of the system. How successful this was can be seen looking at some of the techniques chosen for the implementation.
Programming Language

At the beginning of the project a decision had to be made whether to use a special purpose test description language for the implementation or a high level language with realtime features. The decision fell in favour of Ada. Ada can provide the same level of abstraction by using the package concept as a special purpose language, and additionally has the advantage of a high flexibility in implementing new functions.

The VAX Ada system of DEC was used for the development of the Ada software. Since portability of the software was one of the major aims to be achieved, in the early stages of the project we compiled the packages twice: once with the VAX-Ada compiler and once with the SYSTEAM/ALYSYS Ada system.

The result was that only „trivial“ Ada programs are portable per se. The interfaces to the non-Ada world are rather different; using tasks, even different time behaviours occur. All the differences observed are legitimated by the language reference manual, like:

- different order of elaboration;
- different default priorities for tasks;
- different mechanisms for the selection of the next lower priority task after suspension of a higher priority task;
- different use of input/output operations for the synchronisation which might lead to the blocking of ready tasks with same or lower priority.

Also the different behaviour of tasks influences the design of Ada programs. Therefore a portability guide is absolutely necessary.

Relational Database System

The system has to deal with two different kind of data: on the one hand simple data, like frequency activities which is automatically generated by the measurement devices and gathered at a high speed, and on the other hand very complex data, like network descriptions which is mainly manually generated by the operators.

The database implemented has the following characteristics:

Parameters
65 tables with a total amount of 465 columns
minimum = 1 column, maximum = 21 columns,
average = 8 columns
34 indexes
3 tables have extremely dynamic behaviour with a rate of approx. 30 INSERTs or UPDATEs/sec, the other tables have a much lower frequency rate.
Tuning

The following tuning measures became necessary:

Enlarging the RDBMS parameters:
- Total System Global Area:
  - 532,080 bytes → 1,667,408 bytes
- Dictionary cache entries:
  - from 100 simultaneous entries to 600,
    for columns from 10 to 1,200;
- Separation of the index data from the table data
  by storing in different files;
- Physical distribution of these files on different
  disks of the same or other computers in the cluster
  to improve the access velocity.

Graphical Representation of Data

For the online control of the system and for the
offline analysis some simple graphs are provided.
According to the philosophy to integrate standard
products instead of developing special software, a
simple type of data display was chosen in order to
test the performance of 2 well known statistic
packages. The graph showing the activity of trans-
mitters during a certain period of time displays
frequency vs. time:

```
;Plot frequency activities
loadct, 112
mt = ''
xt = ''
yt = ''
n = 0
xmin = 0
xmax = 0
ymín = 0
ymax = 0
openr, 1, 'datafile.dat'
readf, 1, n
field = fltarr(6,n)
readf, 1, mt
readf, 1, xt
readf, 1, yt
mtitle = mt
xtitle = xt
ytitle = yt
readf, 1, xmin, xmax
readf, 1, ymin, ymax
xmin = xmin
xmax = xmax
!xmin = xmin
!xmax = xmax
!ymin = ymin
!ymax = ymax
xdummy = fltarr(2)
ydummy = fltarr (2)
xdummy(0) = xmin
xdummy(1) = xmin
ydummy(0) = ymin
ydummy(1) = ymin
readf, 1, field
close, 1
!color = 50
twindow, 1, window + 1, 1024, 864, 'bottom nobanner'
plot, xdummy, ydummy
lineplot-
xy, field(0:1,:), field(2:3,:), field(4:5,:),
field(5:5,:), field(5:5,)
inchar = ''
xyouts, xmax/3, 9*ymax/10,"strike RETURN to
continue", 0, 0
read, inchar
tvdelete, 1, window
stop
```

The results of the tests were discouraging:
- the data display on the screen was very slow;
- no standard graph type was available, the graph
  had to be programmed in the BASIC-like language of
  the packages:

Reading the data from a file, for 22,400 samples the
first package took 12 minutes for the data display
on the screen while the second one managed it in
105 seconds. This is not acceptable for a realtime
system, therefore the packages with all their over-
head were not used. The necessary functions were
programmed in Ada using the libraries of X-Windows.
The result was remarkable: the display for 22,400
samples is now done in 10 seconds.
Digital Map Facilities

Digital maps are used for the display of direction finding data (bearings) and the calculated geographical locations of transmitters. The concept of object oriented digital maps was chosen to integrate the maps into the database approach. Again the standard product tested put such a burden onto the system, that at the end a package had to be written in Ada to manipulate digital maps. The data for the maps can be provided either from commercially available databases or by digitizing manually the required maps.

Conclusions

Modern computer hardware and software products allow the development of measurement systems supplying the users with near realtime graphical representation of data for system control and analysis. Some standard products may be used only after a careful evaluation of their performance, overhead and ability of being integrated.

About the Author

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