THE BASIC SOFTWARE FOR THE “TRITON” AND “ACCULINA” – THE AUTOMATED TRITIUM COMPLEXES

Yu.I.Vinogradov, A.V.Kuryakin

RFNC-All-Russia Scientific Research Institute of Experimental Physics
Gas mixture preparation facility

TRITON facility, 1997

Targets

- SDT
  - 5.5 – 60 K

- LTT
  - ~22K

- HPTT
  - 20-800K
  - up to 1600 bar
  - 2 modifications

- HPDT
  - 77-800K
  - up to 1500 bar

4π detector system

Readout system based on FADS

New data evaluation method
The complex for prepares the gas mixture and targets of the TRITON facility.
Structure of the measurement-and-control system

- CGMP subsystem
- Target subsystem
- Monitoring molecular composition subsystem

PC1, PC2, PC3

Ethernet
FLNR JINR: ACCULINA facility, 2000

FLNR JINR:
- U-400M cyclotron
- ACCULINNA separator
- scattering chamber
- detectors

RFNC-VNIIEF:
- Liquid tritium target
- Gas feeding system for U-400M cyclotron ion source

GANIL, Caen, France
Strasbourg, IPN
Brussels University
RIKEN, Japan
Equipment for study of neutron-rich nuclei

- Cyclotron U400-M ion source feeding by the hydrogen isotopes
- Filling of the tritium target by the hydrogen isotopes and $^3$He, $^4$He
- Evacuation and utilization tritium from the target
- Control of working temperature with the accuracy $\pm 0.1$K
- Monitoring of the radiation environment
- Automatic monitoring and control of the working parameters
TRITON and ACCULINA facilities included:

- the gaseus and tagret complexes with automated data acquisition and control systems
- the software for the automated data acquisition and control systems (was made using the programming package developed by the authors)
Motivation for development own programming package

• for operation with tritium need very reliable equipment and software.

• the industrial SCADA-systems (supervisory control and data acquisition) have the “closed” code.

In the case own program we have the total control under the program evolution, available original code and the experience in tritium activity – all these made the software reliable, and its behavior predictable.
Programming package CRW-DAQ

- Our programming package is mini-SCADA system called CRW-DAQ.
- CRW-DAQ is abbreviation of "CuRve in Windows for Data AcQuisition".
- That is graphically-oriented software for design data acquisition and control systems and analyse experimental data.
CRW-DAQ

• The first version of the package named CRW16 designed in 1996 and operated in 16-bit protected mode under DOS/DPMI or Windows-95/98 that corresponded to the level of computers and programs of that time.

• Since 2002 the 32-bit version (CRW32) of the CRW-DAQ package has been being developed for Windows-NT/2000/XP. The source code of the package is written in Object Pascal.

• Site www.crw-daq.ru
Structure of CRW-DAQ package

User terminal
Remote terminal
Data acquisition devices

Base level software
CRW – integrated development and runtime environment
CRW GUI – graphics user interface: editors, plots, consoles, mnemonic schemes…
CRW Math – mathematic analysis, fitting and smoothing, digital filters…
CRW API – application program interface with Object Pascal, dynamic plug-in extension, data import/export…

RTDB – Real time database
Tags
Scalar variables
Curves
Dynamic arrays

DAQ – data acquisition and control system
DAQ Runtime system:
data taking, hardware drivers, control applications…

DAQ control – User control and configuring

DAQ API – application program interface: DAQ Pascal, DAQ Script, DAQ Config languages…

Application level software
Configurations
DAQ Config
Programs
DAQ Pascal
Calibrations
Mnemonics

External programs:
Excel, Matlab, etc.
The base level software

**CRW** - integrated graphic environment for development and execution
- CRW GUI – graphic user interface (editors, plots, mnemonic schemes)
- CRW Math – mathematics analysis
- CRW API – application program interface with Object Pascal, dynamic plug-in extension, data import/export

**RTDB** - real time data base (tags and curves)

**Network protocols** – DIM, TCP/IP

**DAQ** - data acquisition and control systems
- DAQ RunTime system - hardware drivers, control applications
- DAQ control system - user control and configuring
- DAQ API - application programming interface (DAQ Pascal, DAQ Script and DAQ configuration languages)
Application level software

- Configurations
- Calibrations
- Programs on DAQ Pascal
- Mnemo-shemes
Graphic user’s interface

- 2-D plots
- 3-D plots
- Histograms
- Console messages
- Tables
- Mnemonic schemes
Graphic user’s interface
Graphic user’s interface
Build-in programming languages

The build-in DAQ Pascal compiler (designed on the base of classic Pascal-S compiler by Niklaus Wirth)

- is used for developing protected applied programs, so called “measurement scenario”. It generates an intermediate P-code for the virtual stack machine, which is then executed by the build-in interpreter.

The build-in DAQ Script language is C-similar interpreter

- used for the needs of formula calculations in the interactive mode when the calculated expressions are unknown at the stage of compilation (for example, are input by the user in the dialog) and they are to be interpreted immediately.

The integrated Object Pascal command line compiler allows to create dynamic link drivers in the form of *.DLL files, as well as executed *.EXE files usually activated as child processes from the applied DAQ Pascal software and interacting with the program by the anonymous pipe.
CRW-DAQ as multithread application

- The CRW-DAQ systems are worked as the parallel structure.
- The package is made as a multithread application, in which up to 20-30 programming threads running.
- Each driver, system service or applied program (virtual machine) running in a separate programming thread with a regulated poll period and priority.
- Each thread resolves simple task (control a physical device, processes data) and interacts with other threads via messages and real-time database.
- The multithreading is accomplished naturally and doesn’t require big efforts from the applied programmer. The package libraries and functions are developed specially for multithread applications.
a) Successive configuration of computing

b) Parallel configuration of computing
Network systems

For interprocess communication the package includes the technology called DIM (Distributed Information Manager). That technology based on the TCP/IP protocol was developed in CERN for experiments performed at accelerators, the technology realizes the high-level network mechanism for interaction between processes, which is related with the real-time control systems.
Drivers

There is a large set of built-in drivers for distributed measurement devices, and tools for creating new drivers.

- drivers for remote input/output modules marked as ADAM-4000, I-7000
- drivers for adapters for data acquisition and control for the ISA bus DIO-144, DIO-48, DIO-24, PCL-731, PCL-812, PCL-818;
- drivers for controllers for vacuum measurements TPG-256, TPG-252, and the quadrupole QMS-200 mass spectrometer (Balzers Instruments).
- drivers are made in the form of applied programs in DAQ Pascal for cards LA-1.5 ISA, LA-1.5 PCI, LA-2 USB (OJS “Rudnev-Shilyaev”), ELMB (CERN).
Calibrations

- a powerful built-in system for calibration of measurement channels with the database of standard calibrations (12 types of thermocouples, thermal diodes for cryogenic measurements, platinum and nickel resistive temperature sensors, and etc.)
- a set of mathematical tools for fitting calibration parameters over least squares method.
- the operator must do input calibration points and point out for sensor
- the calibration coefficients are automatically calculated.
CRW-DAQ access levels

- the package has self security system which 4 access levels:
- **Lock**—the computer is blocked, all operations are forbidden except the change of the access level. It is used for temporal block of access for unauthorized persons.
- **Guest**—It allows to view curves, observe the state of parameters, but access to the DAQ system control is locked.
- **User**—a level of an (experienced) user, protected by the password. It makes possible to guide the measurement system (start, stop, shutdown) however it is forbidden to edit the applied programs and configurations.
- **Root**—the administrator’s level, protected by the password. This level is intended for developers and responsible persons of the measurement systems.
The CRW-DAQ package includes:

- an advances help system containing a large volume of documents.
- reference book on functions of DAQ Pascal and DAQ Script languages.
- the templates for configuration files and DAQ Pascal programs.
- Demo-programs of the complicated DAQ-systems.
Summary

• We have a longtime successful experience in applying the CRW-DAQ programming package for automation of the research facilities.
• The developed under CRW-DAQ software is very reliable and flexible.
• The CRW-DAQ package used not only in the field of tritium technologies.
Data acquisition and control systems under CRW-DAQ

- JINR, Dubna
- RFNC-VNIIEF
- MSU, Moscow
- SSU, S.Peterburg
- IPM (Inst. Physics of metals), Ekaterinburg
- CERN (Experiment ALICE)