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7.7 NORAC: A new array controller

Introduction

NORSAR personnel have long experience in operating and maintaining arrays and other types of seismic stations, and have over the years also actively participated in array installation work jointly with other organizations. A typical such deployment comprises co-located sensors and digitizers, transmission of data to a central site within the array, and an array controller that performs synchronization, time tagging and transfer of data to a remote data processing facility. Work at NORSAR has traditionally concentrated on development of software for acquisition and processing of data, rather than development of equipment for the field installation. An exception here is the array controller at the FINESA array site, which was largely designed and developed by NORSAR personnel.

We embarked during the spring of 1991 on a new in-house development project aimed at designing a general-purpose array controller that would accept data from various vendors of digitizers, and prototyping of such a unit, named NORAC (NORsar ARray Controller), started during the summer of 1991. The main design idea has been to develop a simple unit that can handle input data from many digitizers. Data processing options and graphics displays would not be part of the array controller design, as these functions can more easily be performed by a Unix workstation on site or at a remote data center. A prototype unit was installed in December 1991 at the NORESS array site and acquired data from one instrument for a period of two months, with real time data transmission to Kjeller. The synchronization and time tagging functions of NORAC have also been tested successfully.

Our current plan is to consider the NORAC unit for use in three different projects now underway, namely, the new high-frequency arrays in Apatity, Russia, and on Spitsbergen, and the NORSAR refurbishment. The exact configuration for these three systems will be different, and the flexibility of NORAC in allowing for different types of communication and also different systems for reception of timing signals is essential.

The following paragraphs offer descriptions of NORAC design requirements, NORAC hardware configuration, NORAC software configuration and a description of how NORAC interfaces to Sun workstations.

NORAC design requirements

At the outset of this development project, the following design requirements were specified for the NORAC unit:

- drivers to different manufacturers of digitizers
- timing of data in the field and support for different clocks such as GPS, Omega and radio clocks
- synchronization of several digitizers from external clock source
- standardized hardware from a vendor represented in several countries
- integration with local or remotely located Unix-based computers

- flexible configurations ranging from 3-component stations to arrays
- option for local recording and archiving of data
- configurable in the field
- communication with remote computer using either asynchronous communication, synchronized communication (SDLC) or Ethernet (TCP protocol and sockets)
- watchdog for automatic restart
- all programs in EPROM/PROM
- should be capable of handling data from up to 32 digitizers

These requirements were largely based on our experience with array controllers at NORSAR, NORESS, ARCESS, FINESA and GERESS.

NORAC hardware configuration

The NORAC unit is based on Motorola VME boards. All boards are standard boards that may be acquired from any Motorola distributor. This subsection describes the different boards and their function in the NORAC unit. The NORAC unit is composed of the following boards:

- Collection board
- Communication board
- Digitizer interface board
- Clock interface board

A system may comprise 1 to 4 boards, depending on the configuration.

<u>Collection board</u>

This board is the main board of the NORAC system. The collection board hosts all programs in EPROM/PROM and typically has 4Mb of memory on board. The configuration of NORAC is stored in BBRAM (Battery Backup RAM) on the collection board. The following functions may be performed by this board:

- time stamp data from digitizers
- synchronize data from different digitizers
- collect statistics
- record data on locally attached disk
- transmit data to a computer using asynchronous protocol
- transmit data to a computer using Ethernet and socket communication
- archive data on tape and disk
- input of timing information using the asynchronous port

A minimum configuration can run on the collection board only. This configuration will contain 1 or 2 digitizers, external time received on the RS232 port and asynchronous communication or Ethernet communication to a local or remote host.

Digitizer interface board

The digitizer interface board has 8 ports for digitizers, its own buffer and CPU. Each port is asynchronous and can run at a speed of 38.4 Kbits/s at the maximum. A NORAC unit may contain as many as 4 digitizer interface boards, thus allowing up to 32 digitizers total.

Communication board

This board is used for performing the SDLC communication. The transmission speed is controlled by the external modem. The board has been tested at speeds from 2.4 to 64 Kbits/s. Data can optionally be compressed.

Clock interface board

We have implemented several options for timing of the data stream. Time information can be retrieved through a special board or from an asynchronous port. The following are the different timing options:

- an ASCII-coded data stream received once a second
- a BCD-formatted word received on a parallel interface
- timing information received directly from the VME bus

There are several different types of clocks (e.g., GPS, Omega and radio based) that deliver time information in one of the three different ways mentioned above.

A system based on an ASCII-coded data stream does not need a special clock board. This time information is read from the collection board as mentioned above.

The BCD-formatted stream on a parallel interface requires a digital input board in the NORAC unit. There are drivers for both Data Translation DT1417 and Acromag avme9460.

We have developed a driver for a VME clock board from Bancom. This board is based on the GPS system.

NORAC software configuration

The NORAC software is designed as a modular system where each task has a dedicated function. All programs are written in C and use functions from SVIDlib. SVIDlib is available through the VMEexec development environment offered by Motorola. All programming (including compiling and loading) is done on a Unix computer running Unix System V. The final system is burned into EPROMs. The following is a list of tasks running on NORAC:

- collect
- todisk
- tosdlc
- toasync
- toether
- fromport
- status

Collect task

Collect is the main task in NORAC. This task synchronizes all other tasks and formats one-second data blocks from all digitizers. Collect updates several statistics and creates all queues used in the system. Tasks such as todisk, tosdlc, toasync and toether retrieve data from a structure in the collect task. Tasks that need statistical information retrieve this from a structure in the collect task.

Todisk task

Todisk writes data onto a local disk loop using the FFS (Fast File System). Todisk can also write data directly on a Unix file system if a Unix CPU is configured into the same system.

Tosdlc task

Tosdlc transmits data on a synchronous communication port using the SDLC protocol. Tosdlc has an option for data compression.

Toasync task

This task uses an asynchronous port for transmitting data. The maximum speed on the asynchronous port is 38.4 Kbits/s. Data can optionally be compressed.

Toether task

This task uses the Ethernet as the communication medium. Sockets are used for establishing a connection between the toether task in NORAC and a task in another computer on the network. The protocol used is TCP/IP for which most Unix computers have support.

Fromport task

Fromport is the controlling task for all ports connected to external digitizers. Fromport has one subroutine for each type of digitizer connected to the system. The following are the digitizers currently supported:

- RD3 from Nanometrics
- RDAS-300P from Teledyne Geotech

- 72A series from Refraction Technology, Inc.

Fromport creates one task for each port with a digitizer connected. Each task is responsible for one digitizer at one specific port. Each task time stamps data from that digitizer as soon as data are received, and transmits data to the collection task which synchronizes data from all ports together in a one-second block.

Other digitizers can easily be interfaced to the system. The only work that needs to be done is writing a subroutine specific for that digitizer in the fromport program. Collect knows from the parameter area in BBRAM what type of digitizer is connected to each port.

Status task

The main function for status is to display statistics, transmit commands to digitizers and configure NORAC. There are also some diagnostic commands available in status. Status is operated from the asynchronous console port on the collect board.

Interfacing to Sun workstations

We have developed all necessary software for interfacing data from the NORAC unit. Data may be received in three ways:

- as an asynchronous data stream. This is not recommended for systems with more than 4 channels
- as a synchronized data stream using the SDLC protocol. An SBUS SDLC board is used as the hardware interface in the Sun workstation.
- as packets on the Ethernet. The Sun workstation is on the same LAN/WAN.

We have developed drivers to all data streams mentioned above. Data are written onto a circular disk loop and archived on Exabyte cassettes. Both the acquisition software and the archiving software are the same as NORSAR is using today for recording and archiving of all existing array data.

R. Paulsen