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The VALET-Plus, a VMEbus based microcomputer for Physics applications

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Abstract

The VALET-Plus is a modular VMEbus based microcomputer system developed at CERN for use in applications such as the development and testing of electronics, equipment control and data acquisition. First released in 1985, more than 100 VALET-Plus systems are used today in 14 countries. The system will be described with particular emphasis on the SPIDER data acquisition package which offers both real time programming, using an interactive language, and fast data collection at rates of more than 1000 formatted events per second.

INTRODUCTION

The VALET-Plus is a modular VMEbus based microcomputer system developed at CERN for use in the development and testing of electronics, equipment control and data acquisition. One of its original design goals was to provide a common tool for testing electronics developed by institutes collaborating in large experiments at the CERN SPS, PS/LEAR and LEP accelerators.

The VALET-Plus consists of two computer systems loosely coupled via a standard link as shown in Fig.1 . On the one side, the VALET provides an optimised environment for connection to the "Physics" buses and on the other side, a (personal) computer acts as an inexpensive peripheral server and provides the user interface.

The application software and libraries execute in a VMEbus M68000 processor which has direct control of the VMEbus, CAMAC, FASTBUS, GPIB, high speed data recording devices and of the Ethernet LAN. Physics data input and output are, thereby, made directly with minimum overhead.

A (personal) computer connected to the VALET via a standard communication link (at present RS-232C or Ethernet) provides both support for standard peripherals such as keyboard, screen, printer, and disk, as well as the interface to control the VMEbus based application processor. These services are provided, in a user transparent way, by means of Remote Procedure Calls (RPC) [13]. The firmware running in the VMEbus M68000 is independent of the type of computer chosen. The communication software ("BRIDGE") in the connected computer is written in Pascal and is, to a large extent, portable. RS-232 has been chosen, despite its bandwidth limitation, in order to minimize restrictions on the user's choice of computer. Since little test application software is disk intensive, the bandwidth limit of RS-232C is rarely an inconvenience. Use of an Ethernet connection to a mini (or personal) computer further reduces this limitation and gives access to other file bases.

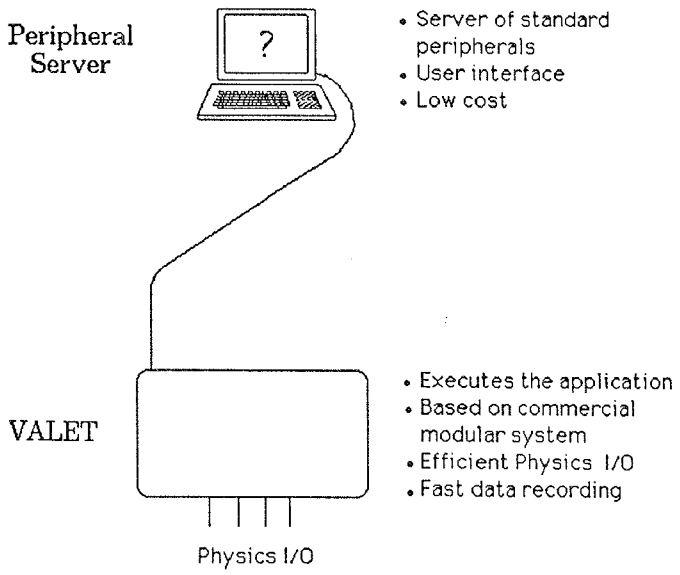

Fig. 1 : The VALET-Plus concept

THE HARDWARE

The VALET-Plus is entirely based on commercially available hardware from a number of manufacturers. This approach takes advantage of the competition in the VMEbus and personal computer markets and it leaves considerable freedom to both the implementors and the users in the evolution of the system.

As shown in Fig.2, the VALET itself consists of [2] :

- A VMEbus crate fully equipped with adequate power supplies and cooling

- Three mandatory VMEbus modules :

  . The Motorola MVME101 processor module
  . An EPROM module with a minimum capacity of 512 kbytes (from a list of recommendations)
  . A DRAM module with a minimum capacity of 1 Mbyte (from a list of recommendations)

- Optional VMEbus modules :

  . CAMAC Branch Driver : CES 8210 (+ DMA option)
  . FASTBUS : Antares / Struck STR302 (includes DMA)
  This module is able to drive the FIORI, CFI and Fast Sequencer FASTBUS masters.
  . GPIB (IEEE-488) : Motorola MVME300 (includes DMA)
  . COLOUR GRAPHICS controller : Eltec GRAZ
  . SCSI interface : Compcontrol CC-74
  . ETHERNET : LRT Filtabyte 25.1

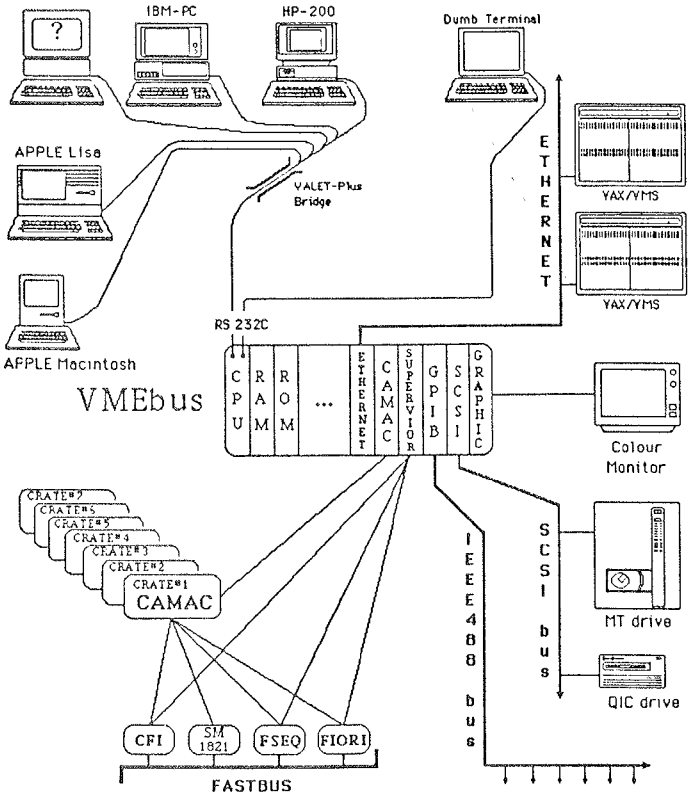

Fig. 2 : The VALET-Plus architecture

THE SOFTWARE IN THE VALET

All software modules in the VALET and the tools to develop programs to be executed in the VALET-Plus are based on CERN standard software packages supported independently from VALET-Plus. Unless mentioned as written in PILS, all the software modules described below are ROM based in the VALET.

MoniCa

MoniCa [11] is a debug monitor for the M68000 microprocessor family. It provides run time support for Assembler and higher level languages such as C, Fortran, Modula-2 and Pascal. Powerful debugging aids are available. A logical channel concept and interrupt driven input/output operations are implemented. MoniCa is written in Assembler and Pascal and is in widespread use at CERN.

PILS

PILS, (a Portable Interactive Language System) [3], is designed to improve the portability of application software and programming environment. It has been installed with identical application libraries on VAX and M68000 based systems. PILS contains ANSI Minimal BASIC as a subset, but it provides additional features such as data types, modules, control structures, subroutines and functions with parameters which create a more powerful language and distinguish PILS from some other interactive languages. A compiler, built into the PILS system, allows improved execution speed whilst retaining the interactivity and is presently available for the VAX and the M68000. The compilation is made entirely in memory (it does not access disk files) and is therefore fast.

The Application Libraries

Standard libraries also available on VAX and NORD systems are installed with PILS:

ESONE / IEEE / NIM CAMAC Subroutines [4]
CERN FASTBUS Subroutines [5]
CERN Histogram package (HMINI) [6]
CERN Graphics (PIGS + Mini-GD3) [7]
Mathematical Subroutines [8]

Additional libraries have been implemented specifically on VALET-Plus as described below :

VMEbus Specific Routines

This is set of library routines providing single and block access to physical memory as byte, word or long word cycles. These simple routines are included to allow convenient testing and debugging of VMEbus modules from PILS.

M68000 Specific Routines

Routines to associate a M68000 exception vector with a user subroutine such that the subroutine is scheduled on occurence of the exception. These routines are particularly useful in real time applications and to develop drivers.

GPIB (IEEE 488) library

A library is available for the Motorola MVME300 module, which has DMA transfer rates of up to 500 kbytes/sec. It is written as a PILS module and it uses the VMEbus library mentioned above.

SCSI library

A library with the necessary primitives to drive devices interfaced to the SCSI is available.

Magnetic Tape (MT) and Quarter Inch Cartridge (QIC) libraries

Libraries with identical external specifications have been implemented to support reel-to-reel and QIC tape drives interfaced via SCSI. These libraries are written as PILS modules using the SCSI library mentioned above.

Timer library

Routines to control the hardware timer chip present on the VALET CPU module. Association of timer interrupts with a user subroutine is possible.

THE COMMUNICATION FACILITIES

ALET-Plus offers several possibilities for communication with other computers. The VALET personal computer / terminal may be used as a remote terminal of a host system connected via RS-232 to the second serial port of the CPU module. For file handling, the services provided include the access to ASCII files from PILS statements and commands, Motorola S-records downloading into the VALET and file copy operations between file bases. File access is based on layer 2 (file management) of the PILS Host Interface (PHI). The implementation uses Remote Procedure Calls (RPC) [13]. The medium can be a serial line or an Ethernet link. For RS-232, a simple ad-hoc protocol was developed. In the case of Ethernet, messages are transferred over raw Ethernet. Time-out and errors are reported but, at present, no error recovery or retry mechanism is provided. For installations with a CAMAC link to CERNET [9], a MoniCa command permits downloading of absolute programs into the VALET processor from any CERNET host. A utility program handles ASCII file transfers between the personal computer disc and any CERNET host.

THE SOFTWARE IN THE PERSONAL COMPUTER

The BRIDGE is the utility program which allows the personal computer to act as a terminal emulator and a server of the remote procedure calls sent from the VALET as shown in Fig.3.

The (personal) computer may also be programmed to provide special user interface features such as menus, windows, etc. depending on the specific type of machine.

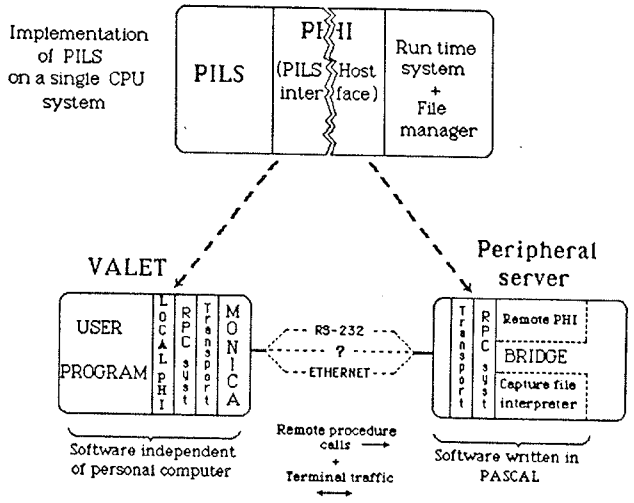

Fig. 3 : The interface between the VALET and its peripheral server

The remote procedure calls are of two kinds :

- File management requests issued by the "local PHI" in the VALET's M68000 and served by a corresponding "Remote PHI" in the personal computer BRIDGE.
- Graphics requests containing records of the "capture file" issued by the VALET graphics library to be interpreted and plotted on the personal computer screen.

The BRIDGE has been written in PASCAL for portability. System specific code such as control of the serial port, file and graphic management is well isolated to ease adaptation between implementations.

The BRIDGE utility has been installed on the following (personal) computers :

Apple Macintosh
Apple Lisa (MacXL)
IBM-PC / MS-DOS and compatibles
Hewlett Packard 200/300 Series
VAX / VMS

PROGRAMMING IN LANGUAGES OTHER THAN PILS

Though primarily offered as a PILS machine, VALET-Plus can be programmed in other languages by means of a suite of cross-software. The CERN cross-software for the M68000 family [10] includes Assembler, PASCAL, FORTRAN 77, C and MODULA_2. With the exception of the FORTRAN 77 and C compilers, the cross-software is written in PASCAL. The compilers generate a common relocatable format (CUFOM) [12] for which link editors and loaders exist. The output of this chain is an absolute image of the program represented as an ASCII file of S-records, which can be loaded by the VALET's debug monitor MoniCa. The cross-software is available under VAX/UNIX-BSD4.2, VAX/VMS, IBM/MVS and on several other minicomputers and mainframes. When substantial non-PILS program development is required, the cross-software should be installed, if possible, on the local personal computer (having good hard-disc support). It has been installed on the HP200 family under the PASCAL Work Station System PWS (with the exception of the cross FORTRAN and C compilers). A command file allows users to link FORTRAN programs to the libraries which are resident in the VALET EPROM. This reduces the number of S-records, and therefore the load time required for programs which make extensive use of libraries.

REAL TIME PROGRAMMING

PILS allows run-time access to subroutine addresses and provides a compiler which generates reentrant code. These features have made real time programming in PILS possible. Standard library calls (e.g. CCLNK for CAMAC) have been implemented together with corresponding interrupt "dispatchers" to permit the association of an external trigger (e.g. a CAMAC LAM) with the execution of a user "event" subroutine.

SPIDER

A simple modular data acquisition package, called SPIDER (Simple Portable Interactive Data acquisition EnviRonment) has been developed for the VALET-Plus. It provides the user with a circular buffer manager, event formatting and optional data recording on MT or QIC drives interfaced via the SCSI bus. It is written in PILS and enables the user to write the monitor program and event read-out routines in that same interactive language. Its modular structure and well defined interfaces, shown in Fig.4, are such that development of a new producer or consumer is easy. With the 8 MHz M68000 processor at present used in the VALET-Plus, SPIDER can collect more than 1000 formatted events per second. The relative execution priority of the competing "processes", which would normally be handled by the operating system in a real multi-tasking environment, had to be provided by some other means on the VALET-Plus under MoniCa. Since the competing "processes" (PILS subroutines) are interrupt driven, the hardware interrupt level priority mechanism is used and the library associated with the trigger bus has been complemented with routines to allow blocking of interrupts whenever a low priority process requires protection (access to global variables, buffer full whilst high priority analysis is selected, etc).

The buffer manager controls the data flow through a circular buffer, the characteristics of which (number and size of sub-buffers), are defined by the user. It supports one input process (producer) and two output processes (consumers) for analysis and data recording. The relative priority between the input and the analysis is selected at start of run.

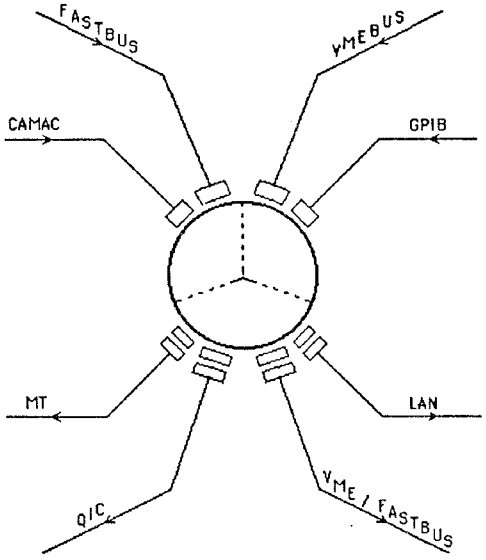

Fig. 4 : The structure of SPIDER

Input is interrupt driven. User subroutines written in PILS and compiled are executed on the occurence of a trigger. At present, triggers can only originate from CAMAC, but support for other sources should be relatively easy. There is an option to replay a run, in which case the input is made from the data recording device.

A set of subroutines permit the program to start and stop data acquisition runs and to retrieve events asynchronously from the circular buffer into a user array. Runs are automatically ended whenever the recording device reaches the end of media or hits an unrecoverable parity error.

Data recording is an option selected at start of run. It is performed automatically (transparently to the user) and concurrently with data taking and analysis. Events and records are formatted according

to the CERN EPIO specification [14]. At present, data can be recorded either on MT or on QIC drives. The independence of the buffer manager from data recording device specific libraries has been achieved by introducing an extra layer of identical high level subroutines for every possible recording "consumer".

SPIDER is easy to use because of its modularity and simplicity (interactive language and standard libraries). Further help is provided by the availability of a skeleton monitor program, examples of user event read-out routines, command files as well as SPIDER control and status subroutines to ease debugging. This package has been successfully used, on a trial basis, by the UA2 experiment at CERN during the Autumn of 1986. It will be officially released in May 1987.

DEVELOPMENTS

Developments will continue mainly in the following directions :

- Integration of new hardware products to improve performance and flexibility of the system and to reflect the market evolution (e.g. M68020 processor, M68881 floating point co-processor)
- Generalization of the use of remote procedure calls to all services provided by the peripheral server (e.g. terminal traffic)
- Generalization of the use of Ethernet / Cheapernet to link to systems other than VAX (e.g. IBM-PC).
- Study of the feasability of porting the VALET software to a multi-tasking operating system (e.g. OS9/68K or RMS68K)
- Integration of VALET as on-line test / spy / pre-processor system into multi-processor read out systems. This implies investigation on processor to processor communication, synchronization and ı itration, resource management, alternate data paths (e.g. VSB).

The use of shared memories and mailbox interrupts by several SPIDER applications running in connection with each other might be a basis for parallel acquisition, event filtering and event building applications.

STATUS

First released in 1985, more than 100 VALET-Plus systems are used today by scientific laboratories and institutes in 14 countries. Most systems incorporate an APPLE Macintosh or an IBM-PC; a few systems use VAX, HP200 or APPLE Lisa. A complete set of documentation [1,2,3,4,5,6,7,11] is available on a self-help basis on CERN IBM WYLBUR service. A VALETNEWS scheme based on Electronic mail has also been implemented to communicate with the user community. Interest in the concept have also resulted in implementations on other M68000/MoniCa based designs such as the FASTBUS General Purpose Master (GPM) by the DELPHI collaboration and on the CAMAC "Controlleur de Branche d'Acquisition" (CBA) by the OPAL collaboration and it is being done on the CERN Host Interface (CHI).

CONCLUSIONS

Originally developed as a simple test system, the VALET-Plus has become, through three firmware upgrades, an efficient data acquisition system with features such as compiled PILS, real time facilities and support of data recording devices. The choice of architecture and standard basic hardware and software components have made this evolution smooth and leaves openings for new developments.

ACKNOWLEDGEMENTS

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