NEW HMI IN CENTUM CS - PICS

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PICS (PC-based Information and Command Station) which utilizes personal computers (PCs) has been developed as a new human-machine interface (HMI) in CENTUM CS. The concepts of PICS are to:

(1) To keep the high reliability of the software with the same architecture as EWS/ICS.

(2) T0 use the PC's CPU performance effectively which progresses dramatically.

(3) To expand the application with an improvement in flexibility.

INTRODUCTION

In order to run 24 hours a day in large-scale plants, such as an oil-refinery or others, a distributed control station (DCS) requires high reliability. In the CENTUM DCS from Yokogawa Electric Corporation, high reliability of each device and a network (bus) connecting devices have been realized by using techniques such as a dual CPU, dual I/O, and a dual communication bus since sales began in 1975. The DCS is a computer-applied product. However, these techniques (redundant techniques and others) are not general techniques for a computer, so we have developed a unique hardware item. With respect to each device, higher reliability has been realized by using highly reliable parts, a redundant memory, and a fan (air cooling device) as well as redundant techniques.

At the same time, along with performance improvements and reductions in computer costs, there is an increasing need to use a general-purpose computer such as a DCS. In CENTUM CS released in August 1993, a general-purpose workstation (HP9000) having excellent cost performance has been used as an engineering workstation (EWS).

In addition, recently, the performance of personal computers (PCs) (especially CPU performance) has improved extraordinarily and personal computers with the equivalent processing capability of a conventional large-scale computer can be obtained at an extremely low price. Therefore, in the same way as with an EWS, there is a strong tendency to use a PC as a DCS device. However, current PCs cannot meet the requirements for a conventional DCS in terms of reliability and maintainability. This prevents users from using a PC as a DCS device.

- The reliability of a DCS must be retained.
- The cost performance of current PCs and the benefit of future PC progress should be given to DCSs.

To meet these demands, a PICS utilizing a general-purpose PC has been developed as a new human-machine interface (HMI) device in CENTUM CS. The structure and concepts of PICS will be described in this paper.

The basic structure of a conventional CENTUM CS is shown in Figure 1. In the drawing, the EWS is an engineering HMI and the ICS is an operation monitoring HMI. Since the EWS uses a general-purpose workstation (WS) as hardware, it also uses UNIX (HP-UX) (a trademark of Hewlett Packard Company) as the operating system (OS).

The ICS is an operator console, which has a unique hardware structure to maintain high reliability. UNIX (SVR4) (developed by AT&T Bell Laboratories) is used as the OS in the ICS in the same way as with the EWS to realize common use of the software.

USE OF A PC IN A DCS

The three main uses of a PC in the DCS environment are as follows:

(1) A PC is utilized outside the DCS environment.

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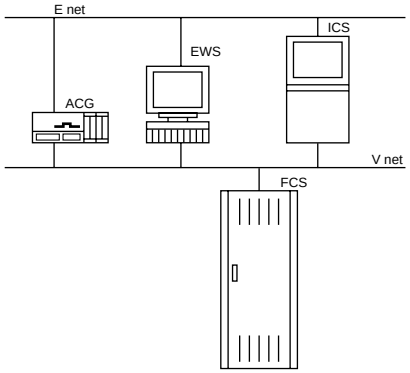

Figure 1 Basic Structure of CENTUM CS

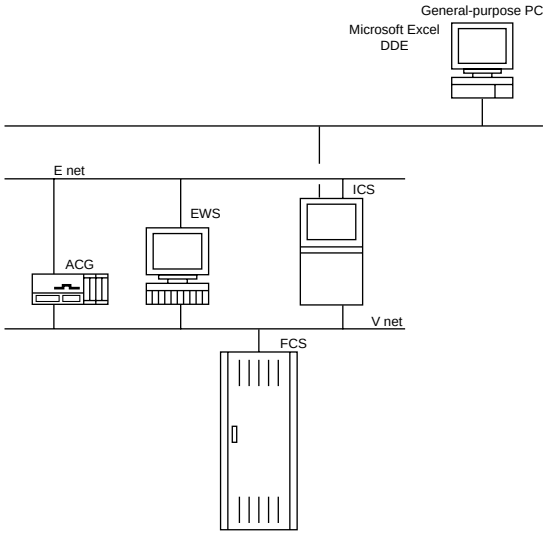

Figure 2 Example of a PC used in a DCS

(2) The DCS is structured on the basis of a PC.
(3) A PC is utilized as a component of the DCS.

1. A PC is utilized outside the DCS environment.

The creation of batch reports such as daily and monthly reports, management of process data, and analysis of collected data which are conventionally processed at the DCS are processed by this PC. The PC is used as a tool by production and technical staffs through operators and the spreadsheet software of the PC is extremely effective in non-routine data processing and graphing. PC software utilized here like this is general-purpose software such as Microsoft Excel (a registered trademark of Microsoft Corporation). The structure thereof is shown in Figure 2.

A PC having this structure is not attributed to the DCS. The object of this structure is for "the DCS to be used for control and for the PC to utilize the DCS data." The following is an example of such an application:

– "TriFellows" CENTUM solution

2. The DCS is structured on the basis of a PC.

Like recent PC instrumentation, there is an example where the operator console comprises only PCs. In such a case, a PC is used in a small-scale system in which a conventional dedicated DCS cannot be used from the viewpoint of price in consideration of reliability and maintainability. In this structure, there are many examples of Microsoft Windows (a registered trademark of Microsoft Corporation) being used as the OS. The following are examples of this application:

– "astnex" open architecture control system
– "QuinSight" simple instrumentation system

3. A PC is utilized as a component of the DCS.

The PICS realizes the application of a PC according to this method. The structure of PICS will be described in detail in this paper. The following is an example of such an application:

– CENTUM CS PC graphic builder

STRUCTURE OF PICS

The PICS is an HMI device in CENTUM CS using a PC as hardware.

1. Function

The PICS realizes the operation monitoring (an operator station function) of a conventional ICS or the engineering function (builder maintenance function) of an EWS. In the PICS, there are some functions which cannot be realized due to hardware restrictions. However, its application capability, including the number of tags, the number of graphic screens, and the number of collected trends it can handle, is the same as that of an ICS or EWS.

2. Hardware

The PC-AT interchanger which is the de facto standard for PCs at present is used as PICS hardware. This hardware provided by Yokogawa is only the operator console keyboard and V-net card. The increase in PC capabilities from generation to generation is fast, so the PC body and expansion card (for example, an Ethernet card, etc.) in the PC-AT interchanger are selected from recommended articles from Yokogawa which are updated every half year.

For a V-net connection, a PC V-net card manufactured by Yokogawa may be used, or connection via a communication gateway (ACG) can be selected in the same way as with an EWS.

3. Software

The PICS uses PC-UNIX (Free BSD) as the OS. As mentioned above, Microsoft Windows is generally the OS for most PCs; however, the PICS dares to employ PC-UNIX. The reason will be explained later in the section on reliability. Free BSD is the most stable OS in PC-UNIX of the BSD system. It can

support numerous peripheral devices and expansion cards and it also has a simple installer function. The source code is written for an open architecture and the OS has outstanding maintainability. The OS is also evaluated as being suited to a real-time system such as the DCS HMI. In the PICS, the operation monitoring function has the same specifications as that of the ICS and the engineering function has the same specifications as that of the EWS.

RELIABILITY

Reliability can be separated into two parts:
- Hardware reliability
- Software reliability

1. Hardware Reliability

The reliability of PC hardware has not been evaluated definitively. In comparison to a DCS with dedicated hardware, there are no sufficient results available on long-term 24-hour continuous use, and it is hard to apply the DCS to the service of a 24-hour system. Namely, it is necessary to use PC hardware on the assumption of damage. However, the PICS uses a general-purpose PC as is, so that it can be replaced along with the PC. In this case, since the PICS uses a de facto standard PC, it can be replaced easily in addition. The reliability of PC hardware can be improved by selecting the most suitable hardware from numerous vendors and machine types.

2. Software Reliability

Software reliability can be further separated:
- System software reliability (provided by Yokogawa)
- Reliability based on the capabilities of the operator and the conventional experience of the engineer

In most PC applications, Microsoft Windows is often used as the OS. In the case of an HMI, it is very difficult to realize the same operability and the same specifications on different OSs (namely, Microsoft Windows and UNIX) and to use the same software between HMIs of different OSs. The use of different OSs in the same system makes it very difficult to maintain software reliability as shown below.

(1) The development resources of vendors differ and cannot be shared easily.
(2) In the case of an HMI, the use of different OSs results in different screens and different operation systems. From the user's viewpoint, they are seen as different products. The differences in screens and in operability is difficult for a user using the two to accept.

In the structure of the PICS, the use of PC-UNIX makes it possible to reuse ICS and EWS software almost unchanged. Namely, the use of PC-UNIX makes it possible to use accepted, industry-proven system software and to provide the same screens and the same operability. By doing this, confusion in operation or engineering can be avoided. The reliability of PICS software becomes attains the same level as that of a highly reliable HMI (ICS, EWS).

FLEXIBLE PICS STRUCTURE

1. Operator console keyboard

To realize operation monitoring by the PICS, the use or non-use of an operator console keyboard can be selected. When an operator console keyboard is used, the operation monitoring function is equal to that of a CENTUM CS desktop ICS. If there is no operator console keyboard available, the PICS provides operability at least the equivalent to that of a PICS having an operator console keyboard through mouse operation. In either case, the screen is the same as that of a desktop ICS.

2. V-net connection

When the PICS is used by the operation monitoring function, the following two V-net connections are available.

(1) Direct connection by V-net card
High performance and highly reliable V-net access are possible. Up to 10 windows can be used for operation in the same way as with an ICS.
(2) Connection via ACG
Recently, Ethernet networks, or FDDIs, have been set up even in user factories while retaining the infrastructure. A wide area network (WAN) using a public (leased) circuit can also be utilized. When E-net of the PICS is extended or connected to the FDDI or WAN, restrictions on the distance between the PICS and V-net are eliminated and the degree of freedom of the PICS in its installation location increases remarkably. This improvement in the degree of freedom of the installation location results in improvement in the degree of freedom the user has. Namely, the operation monitoring function with an ICS which conventionally is operated only by an operator in the instrument room can be run outside the instrument room, and an instrumentation engineer can monitor the plant by the PICS for purposes other than operation.

USE OF PICS

The graph in Figure 3 is the result of part of a survey on DCS users in Tokyo, Japan. Forty-six percent of the users answered that the PICS cannot be operated with a PC, and six percent answered that a PC cannot be used with a DCS. In other words, more than half or of the Japanese DCS users do not think that a PC HMI will take the place of a DCS HMI. The major reason for hesitation to use a PC can be considered to be that users do not think that a PC is highly reliable.

Even if PC hardware is not sufficiently reliable, one of the advantages of using a PC is that the PC is inexpensive. Utilizing this characteristic and the flexible system structure, the PICS expands the HMI for a use different from that of a conventional expensive but highly reliable HMI for a DCS. Namely, the bases of application of the PICS are as shown below:

(1) An environment where there is a larger number of PICSs and operation can be performed by another PICS or the ICS or EWS while the system is down.

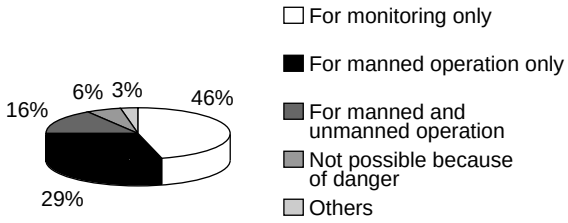

Figure 3 How much can a PC be used for control?

(2) Even if the PICS cannot be used, this is not a critical problem over a short period.
(3) "If the PICS becomes damaged, it can be replaced" is accepted.
(4) The PICS is inexpensive and hardware reliability is a trade-off.

The following uses of PICS are suggested:

1. Sub-operator station

This is an operator station used by an operator in a central instrument room. However, the main operation is carried out with a conventional highly reliable operator station (ICS). There is a big demand for this overseas.

- If more CRTs than usual are required at the startup of a plant, the sub-operator station can be used to support the ICS. If this occurs, the sub-operator station can be operated for other than a monitor.

- If many operators are arranged in a plant and a dedicated CRT is allocated to each operator, the sub-operator station can be used.

Figure 4 shows the layout of a sub-operator station.

2. Additional operator station in office

This is an operator station for personnel other than an operator. The additional operator station is used only for monitoring but performs no operations. The following are suggested uses.

- The situation in a plant can be confirmed on the same screen as that of an operator unless the person in charge of engineering goes to the instrument room and operation by the operator is interrupted.

- The supervisor of the operator monitors the situation of the plant.

Figure 5 shows the layout of an additional operator station in an office.

3. Local operator station

This is an operator station used by an operator in other than a central instrument room. A suggested location is a local instrument room or a site where an FCS and remote I/O unit are installed. There is a big demand for this overseas. The following are examples of suggested uses.

- A local operator station used mainly for monitoring in the local instrument room and also for carrying out an operation

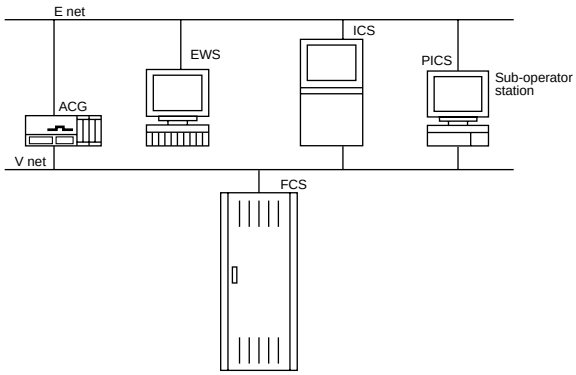

Figure 4 Layout of PICS sub-operator station

- A local operator station generally installed near an operation device in an unmanned location and used by an operator making rounds.

4. Sub-engineering workstation

The sub-engineering workstation is used to supplement the main EWS. In the initial stages of construction of a DCS system where engineering is the busiest, the sub-engineering workstation provides an environment (team engineering) where a number of people in charge of engineering use the builder in parallel at the same time.

5. Small-scale system

The operation monitor and engineering functions are all realized by the PICS independent of the ICS and EWS. To make it possible to continue operation with another PICS even if one PICS goes down, it is recommended that two or more PICSs be installed. Figure 6 shows the layout of a small-scale system.

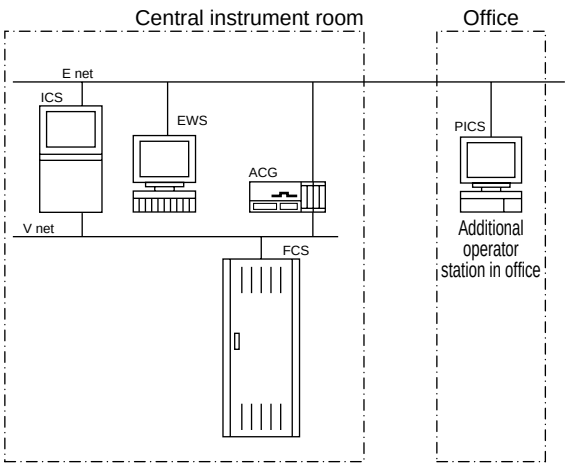

Figure 5 Layout of additional PICS operation station in office

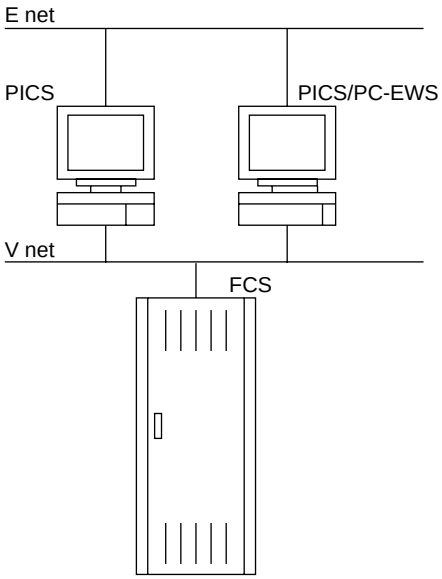

Figure 6 Layout of small-scale PICS system

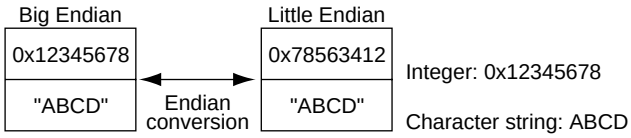

Figure 7 Difference in Endian formats

ENDIAN CONVERSION

The CPU of the PC-AT interchanger used in the PICS is a Pentium microprocessor manufactured by Intel Inc. and the CPU of the ICS is one manufactured by Motorola, Inc. From a historical perspective, the two CPUs are different from each other in the data arrangement system (byte order) in the memory. The Motorola system is called the Big Endian format and the Intel system is called the Little Endian format. Figure 7 shows an example of the difference in the Endian formats.

For example, the 32-bit integer 0x12345678 is arranged in that order in the memory in a Big Endian machine but arranged as 0x78563412 in a Little Endian machine. However, data are not always all different from each other in arrangement, and the character string ABCD is arranged as ABCD in the memory in both machines.

In one computer, there is no need to be aware of the difference in Endian formats. However, when machines having different Endian formats are on the same network, it becomes necessary to be aware of the data arrangement. For example, when a Little Endian machine sends the integer 0x12345678 as is, a Big Endian machine receives the data as 0x78563412. To avoid this, there are rules for sending data beyond a machine in a UNIX system to always change the Endian format to the Big Endian format (Endian conversion).

In CENTUM CS, the following rules currently apply.

(1) Data flowing through the bus (both control and information) is in the Big Endian format (UNIX rule).
(2) A global database created by the engineering function is the Big Endian format (because the database is sent or received via a medium).
(3) The local database of each device and data processing are the Endian format of the local CPU (to ensure performance).

The existing FCSs, ICSs, and EWSs are Big Endian machines, so that items 1, 2, and 3 become Big Endian and no process is changed by this rule. Since the PICS is a Little Endian machine, items 1, 2, and 3 require Endian conversions respectively (Figure 8).

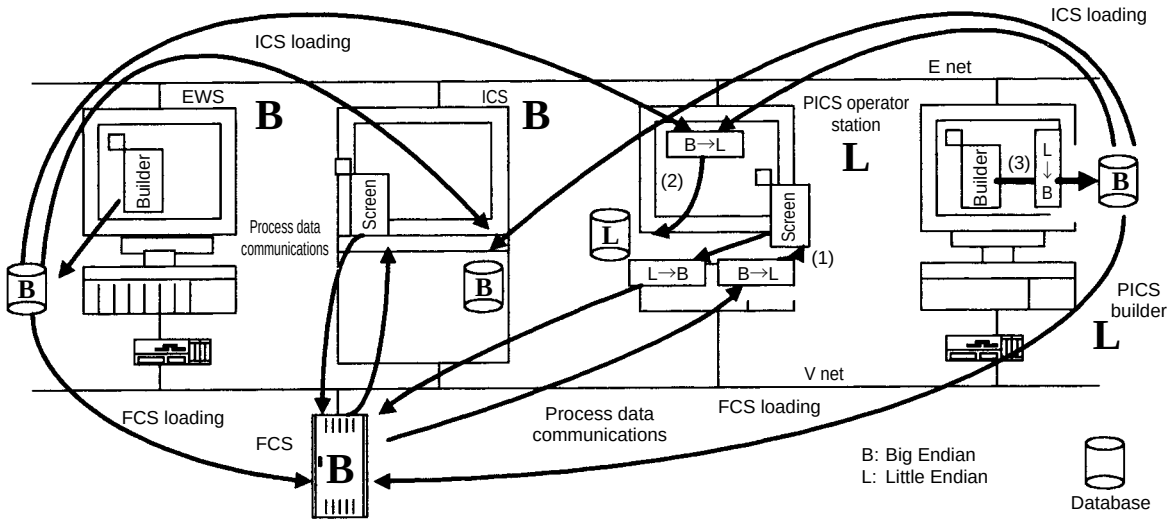

Figure 8 Endian conversion

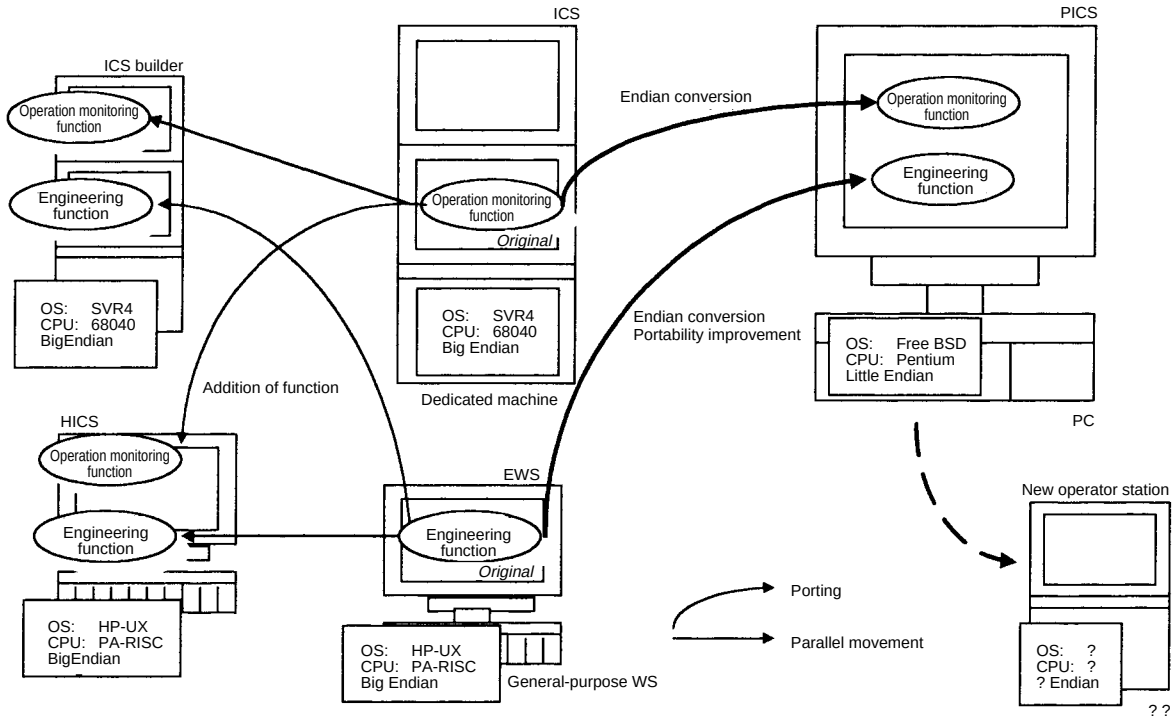

Figure 9 Flow of porting of operation monitoring function and engineering function

FOLLOWING THE PROGRESS OF PC HARDWARE

The expected service life of a DCS (period until replacement) is generally at least 10 years. On the other hand, the service life of a PC is short. PC models are often replaced and the performance thereof improves with each replacement. Therefore, the concept of replacing a PC at a suitable interval (every 3 to 5 years) is more appropriate than the concept of reaching the end of the service life. Only by creating a so-called "industrial PC" through general modifications of a PC to improve on its hardware's low reliability can a dramatic improvement in the performance of PCs be realized.

In the case of PICS, the service life of the software is longer than that of the hardware. To ensure a service life of the system as needed by the DCS, it is necessary to replace the hardware two or three times. To do this, the following are taken into account for the PICS, so that it can be replaced along with the PC at any time.

- A standard PC-AT interchanger is selected as the hardware.
- PC-UNIX (Free BSD) is selected as the OS which can support upgraded PC hardware.

FUTURE

The PICS has been realized by porting the original ICS operation monitoring function and EWS engineering function. In CENTUM CS, the ICS builder (engineering function → ICS) and HICS (for overseas: operation monitoring function → HP9000) have already been realized by porting the original function.

This porting is for including differences in UNIX. In addition, the current PICS is a product that overcomes the differences in CPUs (Endian) (Figure 9). In CENTUM CS, it is intended furthermore to provide an HMI that will meet customer needs based on these improvements and enhancements.

CONCLUSION

The structure of the PICS is a combination of PC hardware rapidly increasing in capabilities and highly reliable and stable software. As the PICS follows the evolution of PCs, the machine having the highest performance will be provided as a DCS. Furthermore, utilizing the features of a flexible structure and low price, the PICS can be applied to new uses. It is our intent to find new uses for the DCS using the material of the PICS.

It is expected that the performance of PCs will improve further in the future just as performance has progressed. If this happens, this will be a major factor in determining whether the PICS is acknowledged as a substitute for a highly reliable HMI in the DCS. After all, the use of a PC in an HMI device in the DCS will surely become more widespread. Finally, we want to thank the "Free BSD Core Team" and its activities in contributing to the development of PC-UNIX. ◆