

ProConOS NT – Realtime Software-PLC on Windows NT

As Windows NT has no determined behavior due to the usual reaction times for fast controllers, a PLC runtime system must be embedded into an appropriate realtime extension. For this reason different realtime extensions for Windows NT are available in the market. However, besides the licenses of Windows NT and the PLC runtime system, this causes additional costs for the realtime extension and/or hardware extensions. Therefore Klöpper und Wiege Software GmbH have decided to develop and offer their own realtime extension as a system solution for the PLC runtime system ProConOS.

So far different computer systems for controller as well as handling and visualizing tasks (HMI) have been often used in automation applications. PC-based systems with Microsoft operating systems – particularly Windows NT – are no longer the one and only solution for operating/visualizing. However, in the control of machines and installations, classic PLC systems or independent controllers with IEC 1131-3-compatible runtime systems such as ProConOS (Programmable Controller Operating System) are still used. Even in the application of PC hardware as an independent controller the PLC runtime system ProConOS is based on realtime operating systems like VxWorks, QNX or RTX DOS.

As PCs are available worldwide, nearly everyone knows how to work with Windows and the efficiency of PC processors continuously rises while prices are sinking, it is logical to integrate also the controller tasks into the PC. As Windows NT has no determined behavior due to the usual reaction times for fast controllers, a PLC runtime system must be embedded into an appropriate realtime extension. For this reason different realtime extensions for Windows NT are available in the market. However, besides the licenses of Windows NT and the PLC runtime system, this causes additional costs for the realtime extension and/or hardware extensions. Therefore Klöpper und Wiege Software GmbH have decided to develop and offer their own realtime extension as a system solution for the PLC runtime system ProConOS.

REALTIME EXTENSION

The realtime extension by Klöpper und Wiege Software GmbH is installed as an encapsulated kernel mode driver in Windows NT. No changes to Windows NT itself are done by this standard implementation. For this reason each available Windows NT system can be used. The compatibility towards following versions of Windows NT remains. This kernel mode driver is called via a timer interrupt independent from the CPU load in regard to cycles and determinations. While the software PLC system ProConOS NT is installed, the cycle time can be selected in the field of 0.5ms to 4ms. Changes of the interrupt mask by the Windows NT kernel or further kernel mode components can cause a delay (jitter) of the context switch from Windows NT to the

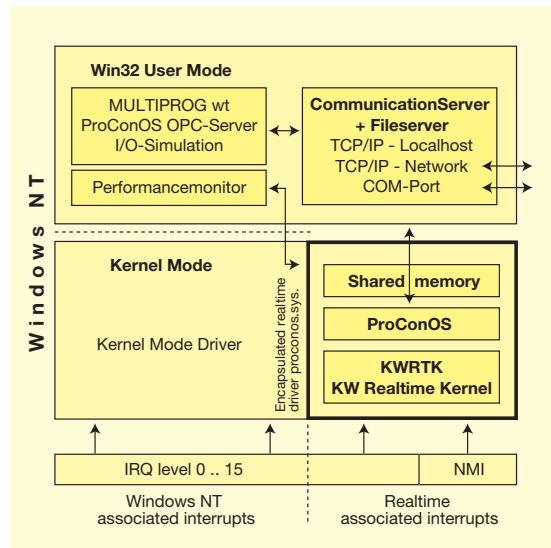


Figure 1. Architecture of the embedded realtime system with ProConOS NT

realtime extension. On a typical Pentium system this jitter achieves 50µs at maximum and is continuously measured and displayed on the basis of the Pentium clock.

A separate realtime kernel (KWRTK) is embedded in the kernel mode driver. After a context switch it offers complete preemptive multitasking including a highly efficient thread switch (<1µs) and 256 priority levels. The interrupts assigned to the realtime extension

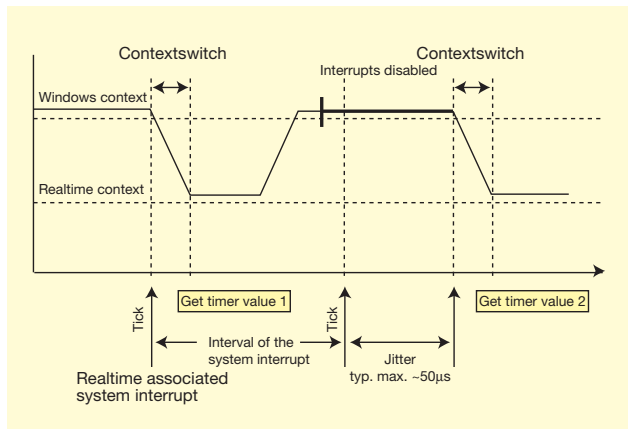


Figure 2. Context switching and system interrupts

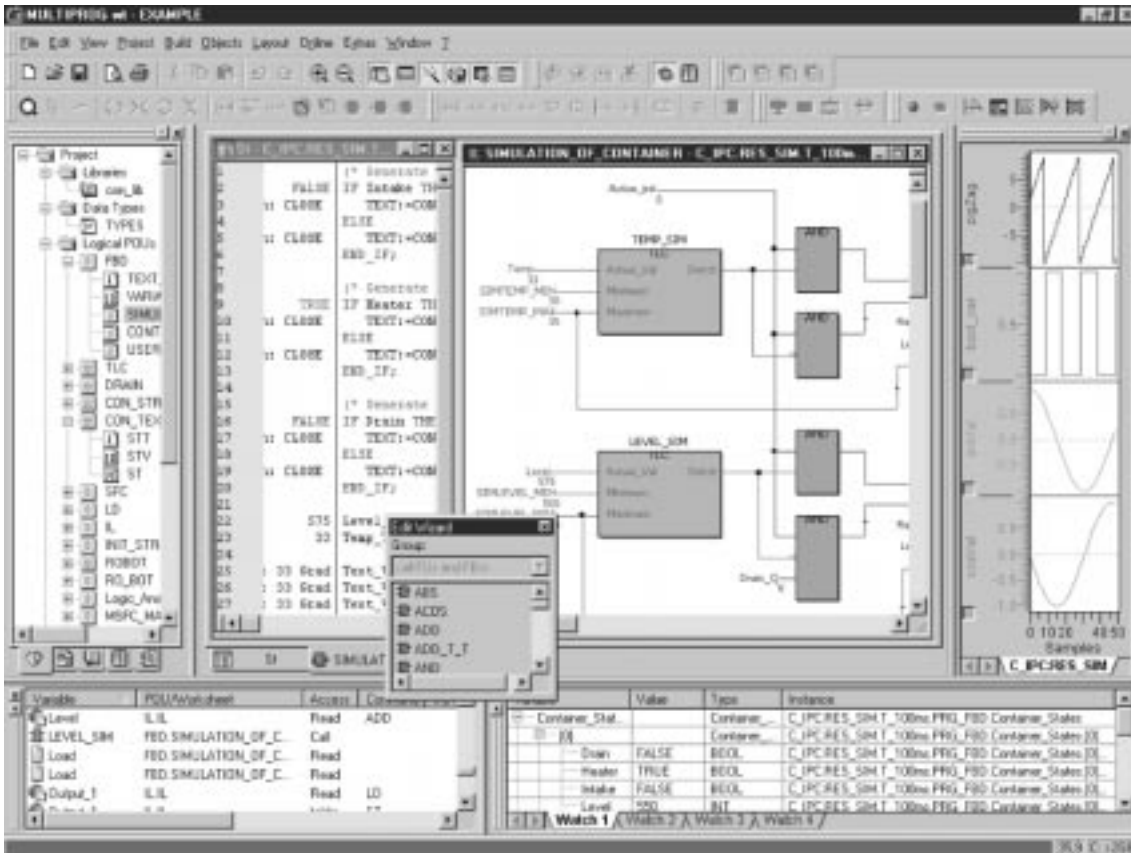


Figure 3. Screenshot of the programming system MULTIPROG wt

within the whole system are handled out of synchronism. ProConOS bases on this realtime kernel and causes a deterministic behavior in a software PLC on Windows NT.

COMMUNICATION WITH WINDOWS APPLICATIONS

A shared reserved memory area is used for the communication among Windows NT applications and the software PLC ProConOS NT. A program including a communication server and a file server is started under Windows NT building up the connection to the TCP/IP ports and the COM ports via this reserved memory area. The communication server enables Windows applications e.g. the programming system MULTIPROG wt or a visualization system (HMI) to exchange data via the TCP/IP protocol locally on a Windows NT system as well as remotely (also Internet and Intranet). For service purposes also a programming unit can communicate locally with the software PLC ProConOS NT via the COM port of the Windows NT system. The file server enables the use of the hard disk of the Windows NT system as a file system for the software PLC ProConOS NT to read bootprojects or INI files or to administrate remanent data.

FIELDBUSSES

The ProConOS NT software PLC takes the general trend away from discrete I/O wiring to fieldbus systems into account. As the selection of a fieldbus system depends on the kind of application as well as the

user's preference, fieldbus masters (PC boards) by Hilscher for INTERBUS, PROFIBUS DP, CANopen and DeviceNet are supported. The available driver can be instantiated up to four times. For this reason, four fieldbus masters (PC boards) of the same or different kind can be simultaneously operated in one single software PLC ProConOS NT. Additionally the INTERBUS master by Phoenix Contact is supported. In general, the configurator belonging to the fieldbus master board is used to project the fieldbus. By a clever address allocation of the used I/O points during the projection it is possible to apply different fieldbus systems without changing the PLC project. This aspect is an advantage especially for export-orientated companies.

SYSTEM BEHAVIOR, PROGRAMMING AND DIAGNOSTIC

The behavior of the software PLC corresponds to the behavior of usual PLCs. When starting the system, Windows NT first starts ProConOS NT, then loads the PLC bootproject and the remanent data (if present) and starts the program execution. When quitting Windows NT correctly (protected by a USV in case of an accident), the program execution is automatically terminated and the remanent data are saved. The PLC programmer can influence this standard behavior by using system tasks for cold start, warm start, stop... For an additional protection, a function block is available for the PLC programmer which offers the possibility to write the remanent data in a cyclic way and triggered by the program during the program execution. During

the operation the performance monitor shows the current and maximum jitter, the CPU load by the realtime extension and the system ticks which have already been executed. Therefore the user always receives information concerning the system behavior. Windows NT and ProConOS NT compete for the CPU allocation of the system where ProConOS NT dominates by the specific implementation. As Windows NT requires a minimum calculation time for its correct function, ProConOS NT is limited to a maximum CPU load of 80%. In addition the realtime behavior of each application task under ProConOS NT is supervised by a watchdog. The project creation and commissioning is done locally or remotely by the programming system MULTIPROG wt. Functionalities such as online status (address status or variable status), program changes while the PLC is running, forcing and overwriting, breakpoints and single steps or variable recording offer the PLC programmer a usual and comfortable workspace. The diversion of the I/O points into a Windows-based simulation even enables a test without the field periphery. An OPC server being capable for networks is used for the data exchange with Windows applications. This standard interface is supported worldwide by the OPC Foundation and terminates the dependence on specific communication drivers in Windows applications.

BLUE SCREEN BEHAVIOR

Many possible users of a software PLC under Windows NT fear the "Blue Screen" crash and thereby the loss of control over the application to be controlled. Such a "Blue Screen" event terminates all Windows applications without control. However, it can only be caused by the Windows NT kernel itself or additionally installed kernel mode components which usually work very reliably. In contrast to several software PLC implementations in the market which work in the user mode of Windows NT, the software PLC ProConOS NT is completely implemented as a driver in the kernel mode. The "Blue Screen" event occurred in the kernel mode is recognized by ProConOS NT in the realtime context after a maximum delay of 4ms. It avoids a new context switch to Windows NT and automatically changes into the stop status with a defined process

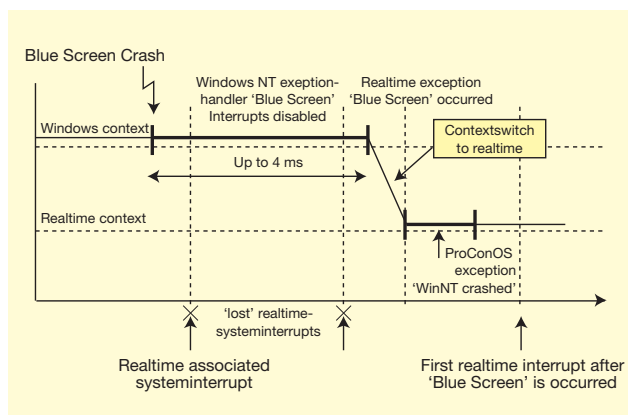


Figure 4. Realtime kernel and "Blue Screen" exception

image of the I/O points. By using a separate system task, the PLC programmer can also cause correcting measures and/or a further program execution. Moreover, in case of a "Blue Screen" event a serial driver of the realtime extension is started to the COM port of the PC. Therefore an external programming unit can build up a connection to ProConOS NT. This specific implementation of the software PLC ProConOS NT grants at any time the secure control of the application and the influence on the controller in case of the rare shutdown of Windows NT.

PROCONOS DEVELOPERS LICENSE

A developers license of the software PLC ProConOS NT offers the system integrator to do his own changes and adaptations of which the most important ones are briefly explained below. In PC systems having an integrated NMI timer on the mother board, the context switch between Windows NT and ProConOS NT can also be done via the NMI instead of a software interrupt. The name NMI (non-maskable interrupt) signifies that this interrupt cannot be driven out by Windows NT. Therefore the jitter for the context switch is deterministically and reproducibly reduced to a few μ s. Furthermore the delay of the program execution is eliminated in case of a "Blue Screen" event. Due to physical causes, it is impossible to write remanent data of processes of a short duration onto the hard disk. However, the simple parameterization of system functions in ProConOS NT enables to write remanent data in a cyclic and consistent way into a SRAM memory. Moreover the function scope of ProConOS NT can be extended by specific functions and function blocks which can be used identically to IEC 1131 functions and function blocks. If the I/O periphery cannot be connected via the fieldbusses supported by standard or the use of intelligent interface boards (e.g. axes control) becomes necessary, self-developed drivers can be linked statically to ProConOS NT to be executed in the kernel mode. If you are using "simple" drivers where the access on synchronization mechanisms or interrupts of the realtime kernel are not essential, developers license with a limited I/O driver is also available.

INTEGRATION

From the production to the planning level, the incompatibility of the systems has so far caused many restrictions to the vertical and horizontal integration in the production. By the triumph of the PC technology on the base of Microsoft operating systems, this vision now seems to become reality. The Soft-PLC ProConOS NT integrated in Windows NT is a further step into this direction. ■

Dipl.-Ing.(FH) Bernd Pelzer works for Kloepper und Wiege Software GmbH, Lemgo and is responsible for marketing and sales of the standard software MULTIPROG wt and ProConOS.