ICP DAS PACs (Programmable Automation Controllers) - the Extreme PC-based Control Systems

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Introductions

ICP DAS has devoted in providing high quality Data Acquisition Systems and PC-Based Control Systems for almost one decade, all advanced PC-based embedded controllers released by ICP DAS posses all characteristics of a PAC (Programmable Automation Controllers) defined by ARC (Automation Research Corporation) Advisory Group. Each of ICP DAS advanced embedded automation controllers is truly already a PAC which combine the best features of both PLCs (Programmable Logic Controllers) and IPCs (Industrial Personal Computers). According to a survey reported by ARC, traditional PLCs are still very much alive in many specific application fields and used in conjunction with IPCs to fulfill those functions PLCs lack. But, both capabilities of PLCs and IPCs are grounded in their natural architectures and limitations. The re-engineering PACs are the result of evolution of control, and help system integrators to reduce the need of hardware. Obviously, the innovative concepts of a PAC would play a vital role in the evolution of automation control. This paper would try to review the history, basics, and benefits of PACs, and to receive brief introductions to ICP DAS PACs.

The evolution in control

- The PLCs (Programmable Logic Controllers)

PLCs (Programmable Logic Controllers), which are physically rugged and designed for reliable real time operation, are specialized industrial computers first introduced in the 1960s for automation control system. The typical PLC hardware architecture is proprietary, and the typical PLC software architecture is fixed to run predefined control loops to scan I/O, to execute user-defined logic, and to communicate to a fieldbus. And a lot of PLC software complies with the IEC-61161-3 international standard to provide specific languages such as ladder logic, digital logic, and sequential function charts for the control logics programming. The reliability of a PLC is mainly due to the hardware and software designed, but these characteristics also limit the extensibility and the flexibility of a PLC. It is true that PLCs are still alive and with potential increase in market, but PLCs need generation upgrade to provide more computing power, sufficient internal memory and storage, standard peripherals, networking interfaces, connectivity to business systems, and flexibility for OEM application software. This is the reason many factory floors today have PLCs used in conjunction with PCs.
• The IPCs (Industrial Personal Computers)

In the 80's and 90's, IPCs (Industrial Personal Computers) are introduced. Because of their powerful processing capacity, standard fancy peripherals, networking capacity and graphical interfaces, IPCs play a key role for supervisory, complex applications, advanced control, HMI, data logging, and enterprise communication. IPCs are derived from commercial PCs and have some improvements in hardware for harsh environments, but, IPCs are still general-purpose computers initially designed to handle a variety of non-real time applications. Although IPCs cooperate with PLCs to benefit and complete whole system with flexibility, advanced functionality, connectivity, and whatever PLCs lack, what engineers dispraise most is their reliability and survivability. IPCs are eventually the same architecture of commercial PCs in the hardware and installed with commercial desktop general-purpose operating systems, the unstable operations, non-determinism of operating system, OS crash, and hard drive crash are always the nightmares of control engineers. However, today's typical control systems are usually hybrid solutions which contain PLCs and IPCs to get the best features of both PLCs and IPCs.

• The PACs (Programmable Automation Controllers)

Due to all above reasons and backgrounds, a new concept is emerged to direct the evolution in the control, the PACs (Programmable Automation Controllers). The word, PAC, is coined by ARC (Automation Research Corporation) Advisory Group which is an international advisory company of thought leader in manufacturing, logistics, and supply chain solutions. ARC identified 5 main PAC characteristics to help users to define their application needs, and these criteria characterize the functionality of the controller by defining the software capabilities. And a PAC can be defined by the following features and capabilities:

• Multi-domain functionality - including logic, motion, HMI and process control - on a single platform;
• A common development platform for the design and integration of multi-domain automated systems in programming, configuration and diagnostics.
• Allowing OEMs and end users to deploy multiple control applications on a single platform;
• Employing de facto standards for network interfaces, languages, etc., to allow data exchange as part of networked multi-vendor systems.

After ARC introduced the concepts of a PAC, lots of leading automation controller providers like Siemens, NI, GE Fanuc, AB and Rockwell, also introduced their PACs, which combine the functionality of PCs and PLCs, and engineers are increasingly using PACs to perform I/O, communications, motion control, and machine automation. The PAC concept will play a major role in plant and factory automation, today and in the future.

To build a better controller

ICP DAS, an international company funded in Taiwan in 1996, is a leading PC-based automation controller provider devotes to manufacture rugged, compact, innovative industrial embedded controllers for field expertise and system integrators. Three years ago, ICP DAS branch office in USA, ICP DAS USA, collected advanced requirements from customers and forward to ICP DAS design center, and one year later, the first advanced PAC named as WinCon-8000 was released. The image we try to introduce to our customers and the first slogan for market is "WinCon-8000 = PLC + IPC + HMI". And almost one year after ICP DAS released the WinCon-8000 series embedded industrial controllers, then ARC coined a new term, the "PAC". Truly our WinCon-8000 series have already satisfied the requirements and possessed the characteristics of a PAC while ARC introduced the concepts of PACs.

The five main PAC criteria identified by ARC are based on software capabilities to characterize the functionality of the controller. As to the implementation of a PAC, a PAC must combine the best features of both PLCs and IPCs to achieve these five functionalities. To summarize it briefly, a PAC should provide ruggedness and reliability like a PLC and flexibility and functionality like a IPC. Traditional PLCs and IPCs are grounded in their functions due to their natural architectures and properties, so we need to re-engineer to build a better controller to create a perfect harmony of these two worlds.
The best features of a PLC

Since a number of automation controller vendors continually release their PACs built of COTS (Commercial Off The Shelf) components, many semiconductor vendors aim at the increasing industrial market to redesign and provide their products for industrial applications. ICP DAS PACs are composed of industry-grade hardware components, hence these PACs are low power consumption, wide operation temperature, and with high protection to guarantee reliability and survivability like PLCs. Also the extra benefits of adopting COTS (Commercial Off The Shelf) components are availability and maintainability of hardware, upgrade of system, and migration of application software.

The ICPDAS WinCon-8000 series PACs are composed of COTS (Commercial Off The Shelf) industry-grade components. The core inside the MCU (Main Control Unit) is a RISC CPU running in 206 MHz speed, along with large sufficient SDRAM, these PACs would provide better performance for system runtime and user applications execution. The WinCon-8000 series PACs also support all sorts of ICP DAS PLC-style I/O modules including I-8000 series, I-87K series, and I-7000 series to provide digital input/output, analog input/output, motion control, and multi-serial ports.

The best features of a Industrial PC

A popular embedded hard real-time Operating System, the Windows CE .NET, is built in internal non-volatile memory of the WinCon-8000 series PACs to provide fast boot up, determinism, and to prevent from system crash. Moreover, the hardware designs of WinCon-8000 series PACs are fanless, diskless, low power consumption, and highly protected.

The Windows CE .NET not only provides stable, recoverable, and robust features of an embedded RTOS (Real Time Operating System), but also powerful OS features, rich functionality, and diversified application development supports like other commercial desktop Windows operating systems. Both of the embedded RISC architecture and built-in embedded RTOS (Real Time Operating System) would provide the best features of IPCs and avoid from all disadvantages of IPCs. Nevertheless, ICP DAS have experienced with I/O technologies and PC-based control for almost 10 years, the innovative WinCon-8000 series PACs are the extreme PC-based control systems developed by ICP DAS to provide reliable industrial PLC-style I/O and flexibility of IPCs.

The PLC Software

A run-time engine of ISaGRAF, one of IEC-61131-3 compliant PLC software, is embedded in WinCon-8000 series ISaGRAF PACs to provide PLC style programming environments. User control logics are pre-programmed in desktop PC and then download to ISaGRAF PACs for application deployments. The ISaGRAF is a PLC-like software running on Windows 95/98/NT/2000/XP. It supports all five IEC61131-3 languages, Ladder Diagram (LD), Structured Text(ST), Function Block Diagram (FBD), Sequential Function Chart (SFC), and Instruction List (IL). Moreover, for the ultimate in power and flexibility, ISaGRAF supports off-line simulation, on-line debugging, monitoring, and real time control.

The PC Software

Like all commercial desktop Windows operating systems installed in IPCs, the Windows CE .NET also provides corresponding reengineered cut-down versions of all features of a powerful operating system. Over 500 software features or components are provided for Windows CE .NET devices. The official Windows advanced programming languages like eMbedded Visual C++, Visual Basic .NET, and Visual C# .NET are also provided for complex application development. Along with diversified software development supports like MFC, ATL, ActiveX, DCOM, .NET Compact Framework, ADO .NET, and Win32 SDK, the same integrated development environment like PCs would highly increase the
The Cost-Effective HMI solutions

To utilize the embedded VGA port for display, the WinCon-8000 series InduSoft PACs are embedded with InduSoft runtime to provide HMI/SCADA solutions. The InduSoft Web Studio is a powerful integrated collection of automation tools that includes all the building blocks required to develop modern Human Machine Interfaces (HMI), Supervisory Control, and Data Acquisition System (SCADA) applications that run natively on Windows XP, 2000, NT and CE/CE.net or in an Internet/Intranet environment. A simple drag and drop, point and click development environment mimics the most complex behavior of your live processes. The Wincon-8000 series InduSoft PACs provide a bundled driver to integrate the application performance and easy to use of software and hardware. It can play as an intelligent distributed data acquisition front end connected to a host machine running a standard SCADA package. User can develop SCADA applications in PC and then download and apply them to the Wincon-8000 series InduSoft PACs. Moreover, InduSoft Web Studio also allows you to save your application screens in HTML format and export them from embedded http server of Wincon-8000 series PACs to web browsers like IE (Internet Explorer). Since WinCon-8000 series PACs provide an openness architecture, standard software support, and industrial standard protocols like OPC server and Modbus protocols, WinCon-8000 series PACs can easily connect and communicate with other third party HMI/SCADA software. Besides InduSoft, there are over 10 international or native third party HMI/SCADA software vendors have ported or are porting their software solutions onto the WinCon-8000 series PACs for international or local market.

The benefits of PACs

To examine today's architecture of control systems, you would see so many things and technologies required to do the functionality required. Different PLCs are adopted in specific control applications, maybe extra discrete I/O devices and DCSs are required, and IPCs are used in conjunction with PLCs to log data, to communicate with other industrial I/O devices and software, to access fancy I/O devices with PC standard interfaces like USB, Ethernet, and Compact Flash, to connect to business systems, and to provide Internet services. Now a multi-functional PAC platform can run all applications in one single controller to reduce the need of hardware, technologies and trouble shooting for integration, and human resource for maintenance. One single PAC would replace several PLCs and one IPC of a previous hybrid control solution.
In the developing phases, since PACs are powered by popular embedded RTOS with rich functionality like a desktop Windows OS, all kind of application program could be developed in one single site and to cooperate with each others. PLC software would help engineers to develop their control applications for I/O control, motion control, process control, and batch control. PC software would help engineers to develop their complex applications for housekeeping, proprietary algorithm, specific devices, and connectivity to business systems. And with supports of standard networking interfaces and protocols, engineers could enable their applications to communicate with third party HMI/SCADA software.

Moreover, due to the open architecture of both hardware and RTOS of a PAC, third party HMI/SCADA software vendors can also easily port their software solutions onto our PACs to provide more diversified cost-effective HMI/SCADA solutions for customers. Moreover, due to the open architecture of both hardware and RTOS of a PAC, third party HMI/SCADA software vendors can also easily port their software solutions onto our PACs to provide more diversified cost-effective HMI/SCADA solutions for customers.

And in the deploying phase, since our high performance multitasking PACs are equipped with rich features of an embedded RTOS and runtime engine of PLC software, both of PLC applications and PC applications could be downloaded to one single PAC for executions. Additionally, reduced target devices would highly decrease the need of human resources for maintenance, deployments, and system upgrade.

The ICP DAS I-8000 series PACs

The I-8000 series PACs are the most compact PACs released by ICP DAS, they are modular network based systems with the capability of connecting I/O either through its own local bus, an I/O expansion, or network extension. Each of I-8000 series PACs is comprised of a main control unit with a range of standard communication interfaces, and an I/O bus permitting I/O expansion. The bus is hybrid in nature providing the facility to connect either through serial or parallel I/O modules. The parallel bus is used for high-speed data transfer. The unit can communicate either using serial communications (RS232, RS485), Ethernet, or CANbus. The Ethernet version of the product supports an integrated web server permitting Internet and Intranet applications. The I-8000 can be used as an intelligent distributed data acquisition front end connected to a host machine running a standard SCADA package, or alternatively it can be user programmed as an autonomous controller running an embedded software application. Significant non-volatile memory is available for data and program storage. The product is made up of four basic components, Main Control Unit (MCU), I/O Expansion Unit, I/O modules, and an embedded proprietary operating system. The proprietary operating system, the MiniOS7 embedded OS, is developed by ICP DAS and compatible with DOS. MiniOS7 has more features than regular DOS in embedded applications, such as shorter power-up time, built-in hardware diagnostic function, direct support for I-8000 and I-7000 modules without a library, and direct support for internal or movable memory devices.

The ICP DAS WinCon-8000 series PACs

The WinCon-8000 series PACs are leading edge embedded platforms with an ARM-core RISC CPU running a Windows CE.NET embedded hard real time operating system. When compared to the standard Window O.S., Windows CE.NET has some advantages, including hard real-time capability, small core size, fast boot up, interrupt handling at a deeper level, and achievable deterministic control. The WinCon-8000 series PACs built of COTS
(Commercial Off The Shelf) industry-grade components with series considerations about high performance, low power consumption, reliability, availability, survivability, and highly protected. Besides the excellent hardware design, the WinCon-8000 series PACs also provide both capabilities of PC software and PLC software such as Visual Basic .NET, Visual C#, Embedded Visual C++, SCADA software like InduSoft, and Soft PLC like ISAGRAF. Also one set of WinCon utilities are of course embedded for system configuration, monitoring, diagnostics, and system upgrade. The embedded VGA port of WinCon-8000 series PACs allow the user to choose a regular LCD monitor instead of the need for an expensive HMI or Industrial PC. They are all-in-one (WinCon-8000 = IPC + PLC + HMI) cost-effective solutions to replace today's hybrid control systems which built up with lots of regular PCs and traditional PLCs. The embedded real time operating system is resident in the flash memory embedded in the MCU (Main Control Unit) of a WinCon-8000 PAC. User programs and data can be saved in external storage areas such as Compact Flash Card and USB drive, or downloaded to RAM at run time through the LAN or USB. The WinCon-8000 series PACs are flagship PACs released by ICP DAS, these PACs provide both best hardware features of IPCs and PLCS.

PC installed with desktop Linux. The LinCon-8000 also support all sorts of ICP DAS local or discrete I/O modules including I-7000, I-8000, and I-87K series. Same as WinCon-8000, the LinCon-8000 provides LinCon SDKs (System Development Kits), including Modbus libraries, I/O accessing libraries, and proprietary VxComm protocols, to support all sorts of ICP DAS local and discrete PLC-style I/O modules, to connect to third party I/O devices, or to interface 3 party software packages. In contrary to .NET Compact Framework capability (Visual Basic .NET and Visual C# .NET) of WinCon-8000 series PACs, the LinCon-8000 series PACs provide JAVA programming capability for hardware independent program development. And in the future, the ISAGRAF version LinCon-8000 PACs would be available soon. ICP DAS just try to develop and release the LinCon-8000 series PACs for those engineers come from Linux world, or for those system integrators who want to use PACs in their Linux legacy systems. ICP DAS would like to also bring the benefits of PACs to the industrial Linux world.

For more information about ICP DAS PACs, please visit: http:\www.icpdas.com, or contact with our services via service@icpdas.com.