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Make Your Own Open Architecture PLC. Reliably!

This article describes how you can build your own open architecture Programmable Logic Controller (PLC). We look at selection criteria for each component separately and address reliability, price, and vendor service. A few defacto hardware standards have emerged. The vendor competition in these segments are continually driving prices down, and this trend isn't about to stop. Whether you're a Systems Integrator, OEM or End User, you can now build your own PLC, and there are compelling reasons to do this.

WHAT IS A PLC?

Your open architecture Programmable Logic Controller has traditional PLC functionality. For example, it's programmable in run mode, has multiple ports for programming and communications, forces I/O, does online searching, and backs up its program and data table in non-volatile solid state memory. It can be programmed with a PC, and can interface with all existing HMI software packages or hardware operator interfaces.

Additionally, this new PLC can operate directly on computer networks (LAN's), making it easy to perform program maintenance and monitoring. It can even back itself up to a file server, and it's probably faster and less expensive than other PLC's. You can even define new building block instructions, which are seamlessly integrated into the programming environment.

Interestingly, your new PLC consists of parts from 3 to 10 of your favorite vendors! You ask, "What? But who has overall responsibility for making it work?" Answer, you do. This is not new. You have that same responsibility every time you buy a traditional "Hard" PLC. Think about it, if a PLC doesn't work you replace the bad part, whether it's a processor, power supply, I/O card, or memory card. You call the vendor and they send you a replacement part; that is, if you don't already have one in stock. You fix it, don't you?

You already know how to replace the parts of a traditional PLC. Your new, open architecture PLC is no different in this regard.

Your new PROCESSOR is an industrially hardened personal computer. But more importantly, it's an open architecture PLC.

In the end, your new PLC gives you the ultimate maintenance luxury: if after several attempts to replace a bad part with supposedly working components,

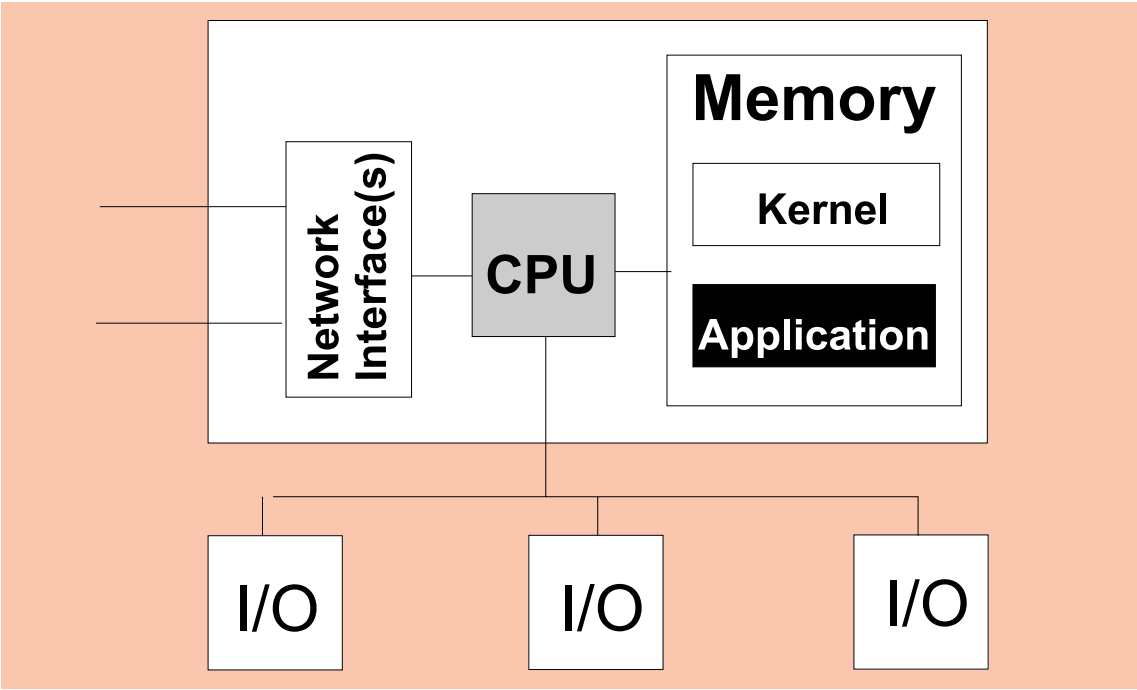

Figure 1.

should it still not work, then you can drop the vendor and find a new one for this component.

I/O SELECTION

This is one of two areas where you need to choose carefully because the cost of switching I/O vendors later is higher than all other areas except one. The actual cost of switching I/O vendors depends on your spare parts inventory and maintenance personnel training investment.

Selection criteria to consider, in order of importance are types of voltages and currents supported, software driver availability, reliability, maintainability, vendor support, size, and speed.

Your I/O vendor choices now include computer I/O vendors. While the PLC revolution was taking place during the 80's, the computer I/O vendors were pioneering new I/O technologies, which in some ways are now superior to traditional PLC I/O. No matter, you can choose from either category now because your new PROCESSOR is an industrially hardened computer and most PLC vendors make adapter cards enabling a computer to run their I/O.

Usually an I/O interface card plugs into your PROCESSOR's backplane and from there you cable over to the I/O. In some cases a third party interface card may be needed. This is like buying an Ethernet card or modem board for your personal computer from somebody other than the computer vendor. It's no big deal.

Bottom line: it's no longer possible for one company to be all things to all people. Sometimes going with a company who specializes in a particular area gives you a best in class solution.

Nowhere near a complete list, but several I/O choices to consider are Profibus, GE Fanuc, Interbus-S, Allen-Bradley, COMARK, and GE Fanuc. The GE Fanuc Series 90TM/30 I/O interface card (-PCIF) is a good buy, listing at less than $100. COMARK and many other companies make direct plug-in cards or serial I/O that don't require an interface card.

I have seen Users contact their existing PLC vendors and insist that they make an I/O interface card for AT ISA bus, so they can continue using their existing I/O with their new open architecture PROCESSOR. This lets the End User retrofit existing PROCESSOR installations with the new open architecture PROCESSOR and achieve the benefits of superior networking immediately.

PROCESSOR SELECTION

There may be no need for a monitor or keyboard at runtime. These are liabilities and decrease system reliability. Non-I/O communications with the PROCESSOR should take place either over a LAN, serial port, or backplane, just like a traditional PLC. Some KERNEL's require a monitor and keyboard, with others they are optional and may be helpful for diagnostics.

You should treat each PROCESSOR component separately. They may not all come from the same vendor. Bus architecture is most important. You get the most options and best prices by sticking with AT ISA bus. Industry Standard Architecture is just that.

Some large End Users opt for ISA coprocessors, which may be housed in anybody's personal computer or industrial workstation. COMARK makes hardened ISA coprocessors like this with PC-104 mounting sites for interface adapters, giving you a PLC PROCESSOR on a card. You are not limited to ISA however. For example, Ziatech makes CompactPCI bus boxes, which

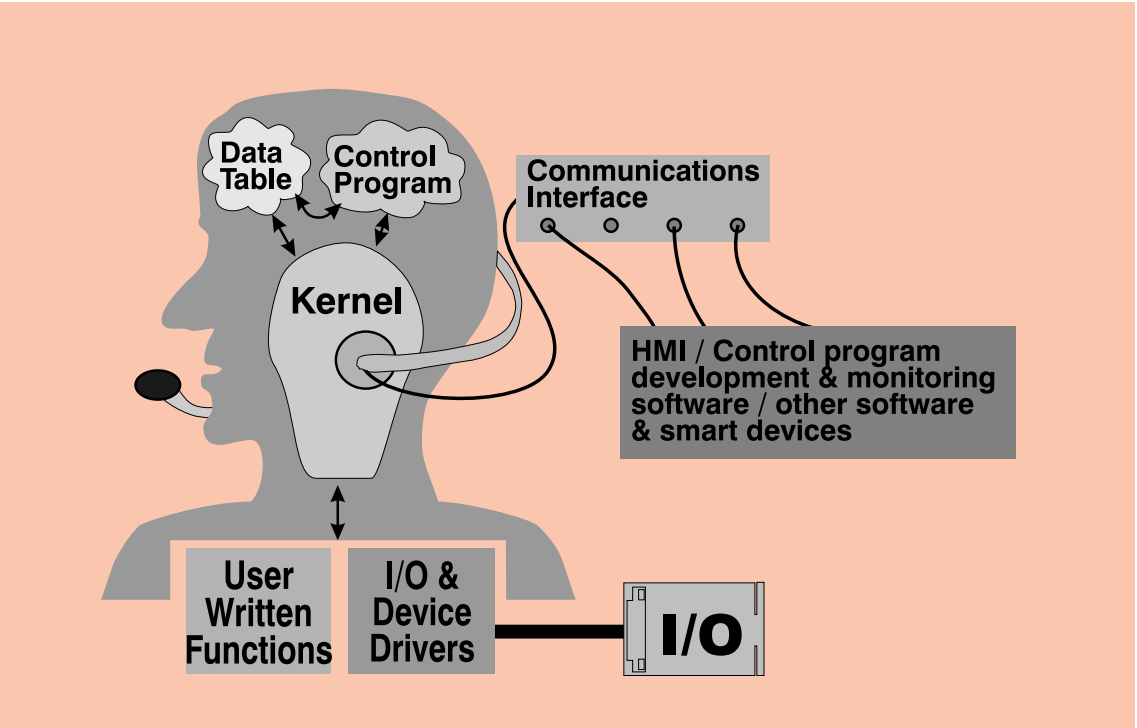

Figure 2. Example KERNEL architecture

offer multi-CPU solutions.

My preference is the ISA industrial shoebox. It is a dedicated box that is about the size of a small shoebox. It has industrially hardened components rated at least 0-50oC. Your baseline shoebox PROCESSOR should have a hardened power supply and a passive ISA backplane. Unlike a desktop computer, the CPU and MEMORY should be contained on one or more separate plug-in cards housed on a passive backplane, where they are easily replaced in the event of failure or upgrade.

If vibration is an environmental possibility, use a box which has a hold down bar across the front edge of the plug in cards opposite from the screw-down bayonet.

Several vendors to consider are TFI, Mitac, Texas Microsystems, and Consyst. Keep the door open to PCI bus. Its higher performance, jumper free configuration, multi-master architecture, and mainstream desktop usage, make it a potential winner for the future.

After bus architecture your next most important criteria is price, followed by vendor service. There is little or no cost for you to switch PROCESSOR vendors. Make sure your PROCESSOR vendor knows you expect good service and don't be afraid to change. Let the laws of supply and demand work for you. You are the customer.

CPU AND MEMORY SELECTION

There are a number of excellent CPU cards available. Having MEMORY on-board the CPU card means the CPU doesn't have to go across the computer bus to access memory. Soldered connections are more reliable than the physical contact points of the ISA bus connectors. Likewise, choose surface mounted (soldered) parts over socketed parts. Select MEMORY, which does parity checking.

You need 3 types of MEMORY: 1) AT bios firmware, 2) 4 Mbytes of dynamic RAM, and 3) 4 MB non-volatile battery backed up SRAM disk or FLASH disk or both. Type 3) is a solid state disk. Avoid mechanical disks, which have rotating parts. PCMCIA memory adapters and cards are available for ISA bus. These cards give you a nice credit card sized portable solid state disk for easy transportation of control programs, and can be useful in the event you don't have a LAN.

The newer FLASH file systems allow you to use a simple DOS copy command when writing to FLASH. The older type requires you to create a disk image first. You want the newer type for convenience, although it does cost a little more.

Go with a hardened CPU card, rated at least 0-50oC. For about the same cost, you can find some rated 0-80oC with an MTBF of 25 years! Economies of scale make your best buy a 486 CPU, although the 133 MHz Pentium is taking this title over. Unless you need the speed of a Pentium, a 486 class CPU will also provide a more reliable system since the chip generates less heat and doesn't need a fan.

Although you may not have a monitor, keyboard, or floppy connected at runtime, some CPU cards have interfaces for these devices on board to facilitate installation of the KERNEL. After KERNEL installation, the monitor, keyboard and floppy may be removed.

Some vendors to consider are TFI, MicroPC, and Advantech. Criteria, in order of importance, are reliability, price, vendor support, and new FLASH file system support. There is little or no cost to swap CPU/MEMORY vendors. You should find what you need for under $500.

NETWORK Interface Selection

You hit pay dirt. Your new open architecture PLC capitalizes on all the tremendously innovative advances in the personal computer networking field. Traditional PLC networks now serve only one purpose: to lock you into that particular PLC vendor.

There's lots of competition, economies of scale, and great minds at work in the personal computer networking field. 100BASE-T Fast Ethernet is available now for less than $100/card and no proprietary control network approaches it for speed. Reliable 10BASE-T cards can be purchased for about $30.

Use 10BASE-T or 100BASE-T Ethernet network cards. Later, consider adding an Ethernet switch to your LAN to partition your control network segment from your MIS network segments into a separate collision domain. It will all remain one LAN however.

Some KERNEL's let you add the new PROCESSOR to existing PLC networks, and can simultaneously use IPX protocol from NOVELL and/or TCP/IP so you have all the best of both old and new worlds.

KERNEL SELECTION

The KERNEL is the runtime software component, which converts the industrially hardened computer into a PLC. This is your most important component selection.

When you select a KERNEL vendor, you select that vendor's philosophies and know-how, and there are a number of important differences to be aware of. Some KERNEL vendors want you doing HMI, logging, and control all on the same CPU. Others vendors are conservative and more conscious of reliability issues.

The question not to ask is whether you can effectively perform control, HMI, and logging all on the same CPU. The real question is "should you?" What do you gain? One cubic foot of plant volume because you have one less computer box around? A few dollars in hardware savings? How about a few kilowatt-hours? These gains are trivial in comparison to the cost: seriously decreased system reliability, non-deterministic performance and increased complexity. Who is going to maintain and troubleshoot the system?

My company, SoftPLC Corp., offers a control KERNEL called SoftPLC. Our philosophy and experience has brought forth a very conservative approach to this business. We are able to look the customer in the eye and say in clear conscience that when he installs our KERNEL on his industrially hardened computer hardware, that he truly gets a PLC. Our opinion on this matter is strong and comes through in the following example.

You might hire a part time secretary to do typing or

bookkeeping for you. She might even carry a pager so you can call her when you need her. When she is not needed she can work other jobs across town. No problems here. These are non-mission critical jobs.

What about running your plant? Would you hire a part time operator and leave your plant unattended for any amount of up time? Part time wouldn't be right, even if the operator has a beeper. What if the operator were to get bogged down in other jobs or get caught in traffic traveling across town?

This is your first KERNEL selection criterion. Do you go with a vendor who wants you to dedicate a CPU or do you go with one who encourages you to take risk. Remember this: There's reliability in simplicity.

Multi-tasking operating systems are not simple. Windows, OS/2, Windows NT, etc. are good platforms for HMI or programming software, but they are not platforms on which to base a PLC KERNEL. How many times have you rebooted your Windows lately? How many of those times would have been acceptable in a control environment?

Your next most important selection criterion is ease of learning. How familiar are your people with the programming model used by the KERNEL? Do you already know ladder logic, flow chart, statement list, etc.? What is the best match for your people?

Is the system open architecture? Is there a toolkit enabling somebody other than the vendor to add I/O drivers and new instructions?

Other issues are the features of the programming editor. Can you do run mode programming? I/O forcing? Online search and replace? Non-sequential rung display? Data table watch windows? Intelligent program difference detection? Is there program documentation support, rung comments, tagnames and address labels?

Can you do offline simulation and testing of the application logic? Can you include a process model in that simulation?

What kind of networking support is there? Some KERNEL's can coexist on both existing PLC networks and personal computer LANs.

What other products does the vendor have? How much experience in real time control do they have? How long has the company been in business?

Speed is not a particularly important criterion, because in the unlikely event the software is not fast enough, simply buy a faster CPU. By the time you look twice the faster hardware will have halved in price.

If you're uncomfortable entrusting your plant to a small software firm as most KERNEL suppliers are, ask them if they will put the source code into escrow. That way if they should go out of business, you can get the source code.

Company size is not a particularly good measure of expertise, nor stability for that matter. A smaller company can be more responsive to your needs. In this day of legendary customer service objectives, finding a customer driven KERNEL vendor is not hard. Just call me if you need help.

SUMMARY

You may have other specialized requirements. An open architecture hardware and software system means you are never locked out or in. There are plenty of plug-in cards and drivers and Systems Integrators who specialize in assisting people in building these kinds of systems. A consequence of reorienting toward open architecture systems is that vendors become LESS important, and your relationships with System Integrators become MORE important.

Your completed PROCESSOR may only have 2-3 cards in it: CPU/MEMORY, the I/O interface card, and maybe an Ethernet card. Excluding the software KERNEL and I/O interface, you will be able to put together a PROCESSOR hardware solution for under $900, today. Tomorrow it will cost even less.

Mr. Hollenbeck has a BS in Chemical Engineering and has worked as an Applications Engineer and PLC Sales Manager at Allen-Bradley Company (now Rockwell Automation). He is CTO of SoftPLC Corporation. His second language is German. He has studied at Brown University, Universitat Karlsruhe Germany, and University of Winsconsin Madison.