White Paper

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Chasing Moore's Law – The Truth Behind the OS and CPU Upgrades for Industrial PC Users

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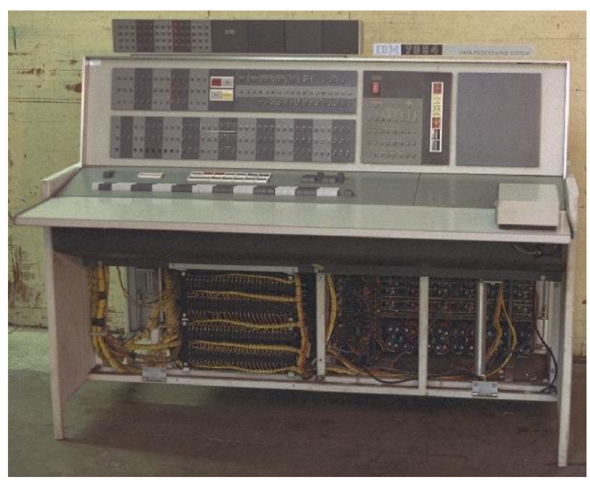
What hath COTS wrought?
The COTS effect has been almost as big a revolution as that signaled by the phrase uttered by Alexander Graham Bell, "What hath God wrought?" COTS is a three letter acronym that stands for "Commercial, Off The Shelf," and the COTS revolution has changed commercial computing, created personal computing, impacted telecommunications, and made huge changes in the industrial environment. Most of these changes have been incredibly beneficial. Some have made technologies practical and affordable for applications that were unthinkable thirty years ago. Some have been problematic and some have caused significant FUD. (FUD is another three letter acronym, standing for Fear, Uncertainty, and Doubt.)

The COTS revolution
Beginning in the 1970s, electronics manufacturers started to use mass produced components and then integrated circuits to drive down the cost of devices. They began with "transistor radios" and ended in the present day with PDAs, inexpensive laptops like the ASUStek eeePC and throwaway cellular telephones.

Manufacturers standardized on a small palette of components because it allowed them to use economies of scale and economies of design and manufacture to drive features *up* while driving cost *down*. The COTS revolution has affected every part of commercial and industrial manufacturing, enterprise operations and even individual lives. COTS electronics hardware is now found in everything from electric blankets and washing machines to automobiles to industrial controllers and robots, along with office machines and communications networks. Manufacturers like Intel and AMD, for example, make millions of a single design of chip, allowing that chip to be made for a per-each cost that is incredibly small when compared to the per-each cost of the first VLSI integrated circuits made in the 1970s.



But it is in the combination of COTS electronic hardware and COTS software that the real synergies—and the incredible new technologies have emerged. And it is this combination that has caused real problems for the industrial PC users who have benefited the most from it.

Here's an example of the COTS software revolution. In 1975, the average word processing software suite cost more than $3000. The operating system for what was then the lowest cost minicomputer system, the DEC PDP-11, cost over $10,000. Hardware costs were similar. In 2007, the cost of a word processing software suite ranges from "free" to about $300. The cost of an operating system ranges from "free" to $400. The cost of a computer to run them on runs from $200 to $5000.

Chasing Wintel

The business model for the COTS revolution is to make a whole lot of the same product, sell them all, and then supersede them with something bigger, better, faster. This holds true for both hardware (CPUs, memory, storage, peripherals) and software (OS, office suites, other applications, etc.).

Vendors, in order to continue to operate, must release new products on a regular basis, and stimulate the market to buy by providing new features. They also stimulate turnover by dropping support for older models of hardware and outdated versions of software.

Every new OS has many more features than the previous generation, and requires faster CPU performance (increased demand for new hardware) much more disk storage (increased demand for new hardware again) and more memory (even more increased demand for new hardware) than the earlier version required.

In fact, in order to maintain the same performance to the user when upgrading to a new OS, the CPU must have two to ten times better performance than the old CPU that worked fine with the old OS.

When the OS grows, the CPU must get faster. This means that the CPU runs hotter. It also means that the CPU must have more and faster DRAM (memory), which also means more heat. Multiple cores (Dual and Quad Core CPUs) require advanced power management in order to control heat, and power demand.

With the growth in DRAM comes the additional need for more storage. Conventional HDD (hard disk drive) technology also produces more heat for larger sizes of drives.

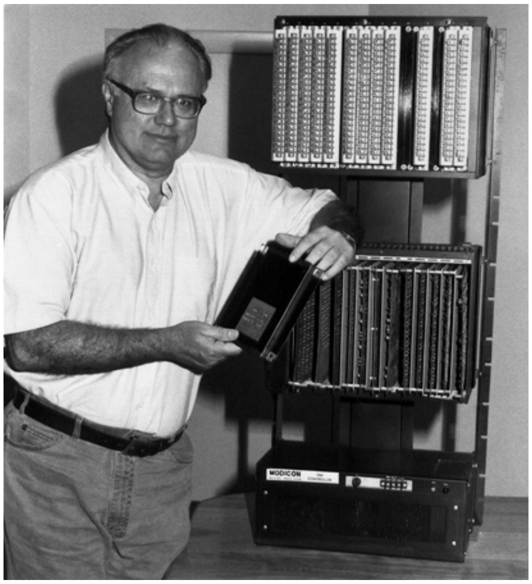
This is a spiral that actually works well in commercial and personal computing applications. There is a very large market for essentially similar products that can be used in numerous essentially similar applications in a wide variety of commercial and home computing situations. Office and home computers can be upgraded on a regular cycle, every couple of years for laptops and desktops, every year for servers, every couple of years for software and applications suites and services. Most upgrades in these situations happen because there are features in the new computers or new software that appeal to the users, or because the older hardware and software are no longer performing properly and have gone to obsolescence and non-support by the vendor.

In the commercial and personal computing markets, and in the telecommunications industry that has been spawned off of them (VoIP telephony, PDAs, cell phones with Windows operating systems, etc.) this has been the engine that has driven the COTS revolution—this spiral of upgrading has made it possible to drive quality and performance radically higher while at the same time driving cost radically downward. Fundamentally, this has been a good thing except, the flip side comes later.

Industrial Good News

One of the biggest beneficiaries of the COTS revolution has been the industrial controls industry. In 1975, almost all controls were single relays or single loop controllers. Some controllers were still pneumatic. As the COTS revolution progressed, control systems migrated to conventional single board computers and controllers, and HMIs that run on conventional operating systems. A classic example of this is the program LabVIEW which was developed for the first graphical user interface, the Macintosh. LabVIEW is the direct ancestor of all graphical programming languages and HMI (human machine interfaces) but it required the development of a COTS microcomputer that was developed for personal computing for its own creation.

By 2008, the very definition of a distributed control system (DCS) has changed. In 1975 when the Honeywell TDC2000 was introduced a DCS was a dedicated proprietary computer system connected over a proprietary data network to a set of dedicated proprietary field controllers. A modern DCS is an integrated proprietary software suite running on the Windows operating system, on COTS microcomputers, connected over Ethernet to a series of proprietary field controllers and sensor networks.



In addition, the industrial controller market itself has migrated far into the COTS world. In 1968, when the first Modicon programmable logic controller was being created, it was an entirely proprietary device, with a proprietary operating system and proprietary programming language. In 2008, a typical programmable automation controller uses a single board computer based on the Intel chipset, and often runs some variation of the Windows operating system, and just as often, has a standard, Windows-based HMI either attached by cable or even embedded.

In addition, there has been a progression from "islands of control" in the 1970s to fully connected plant operations networks in the 2000s. And while early industrial controls networks were proprietary, modern networking is almost always standards-based and uses either COTS or industrially-hardened versions of COTS designed networking hardware.

And exactly as has happened in the commercial and personal computing space and in telecommunications, the use of COTS derived hardware and software has forced performance and quality *up* while simultaneously driving costs *down.*

The Flip Side of COTS for Industrial Applications

So what's the problem? The problem is that even though control systems have benefited greatly from the COTS revolution, they have begun to benefit less and less as each operating system and CPU revision cycle has passed. For example, a commercial laptop can be purchased for less than $1000. An industrially-hardened tablet PC sells for twice that much, or more. Sometimes, this means that COTS commercial PCs are being used for cost reasons, where Industrial PCs would be clearly better. What it also means is that the benefits of COTS for industrial applications are breaking down.

Many industrial applications run in harsh environments with wide temperature ranges and contaminated air, and require sealed computers with no fans, no heat exchangers, and often require lower power consumption than commercial and personal computing applications do. Some industrial applications simply do not permit typical power management and heat management schemes to be used, because they have to operate at 100% of core utilization, running at maximum core temperatures.

Many control applications do not require the sophisticated new services and graphics capabilities of Windows Vista and do not require the Intel and AMD CPUs designed to run latest generation OS and software application suites.

Many control applications cannot afford yearly replacements and expect at least five to seven year service life (or sometimes even longer). This contrasts poorly with office and enterprise laptops and desktops that have a one to three year replacement cycle. New enterprise software applications also drive the upgrade and replacement cycle, where industrial control applications often do not change for years.

Memory upgrades continue to be expensive, and industrial grade DRAM, which can tolerate large excursions in temperature, vibration, or dirty power, is extremely costly. Hard Disk Drives continue to be relatively fragile, and relatively costly, and have real issues working at the temperatures and service factors commonly encountered on the plant floor. Flash memory for storage is getting less expensive, but flash drives are still expensive and slow in comparison with conventional HDDs.

Above all, there is the problem of thermal management. A sealed computer can dissipate roughly 30 watts passively, without fans, forced convective airflow or expensive Peltier coolers. That's in an industrial ambient environment from -20^{o} to +70 ^{o}C. Many applications actually require (and some exceed) ambients from -40 ^{o} to +85 ^{o} C. Contrast this with the power requirements of a typical Dell Core 2 Extreme desktop at 450 watts. Most COTS computers running Windows Vista are similar in power requirements. To use a COTS microcomputer like this, or even an industrially-hardened version of it, expensive power management systems and custom industrialized enclosures must be used. Worse yet, reliability is an issue—high density, higher heat, faster speed, and RoHS, yields a less reliable, less durable product. This is fine in a one-to-three-year turnover commercial product, but is not acceptable in the industrial controls environment.

The other issue is that industrial control applications, once the line or process is designed and built, often do not change for years. New capabilities for graphics, embedded services, and networking are simply unnecessary for these applications. In fact, many control applications could run very well on older x86 processors for many more decades.

As the COTS spiral grows, the commercial manufacturers of computer hardware are beginning to abandon manufacture of older, smaller CPUs, memory and storage. Serial and parallel connections, still ubiquitous on the plant floor, are practically nonexistent in modern COTS computers. Intel is slowly dropping low end CPUs for lack of demand.

What is the Industrial Computer User to Do?
The industrial beneficiary of the COTS revolution needs to decide whether to continue to ride the development spiral. The question that needs to be asked is, “Do my applications require the fastest Intel or AMD processors, the biggest HDDs, and the latest edition of Windows Vista and all of the standard Windows services and application suites?”

If the answer is “no,” the industrial computer user needs to consider some options.

Several computer companies are beginning to produce very high integration single chip computers (SOCs—“system on chip”). Intel is producing an SOC, AMD has its GX series, and Advantech is producing its EVA SOC series. All of these are x86 devices, like the venerable Intel 80486, and some operate with extremely low power consumption and low to midrange CPU performance. Most are perfectly adequate for embedded computing, single board industrial controllers, and HMI requirements for the industrial computing market.

To run these SOCs, the industrial computer user will probably need to look at Linux or some other configurable OS, like QNX, CE, or embedded versions of Windows XP (eXP). eXP, for example, is very stable and produces a reasonable OS size around 700 Kb, and, with a 2 Gb CF card for storage, provides a good performing device. The other configurable OSes have a strong advantage in that they have no planned or forced obsolescence drives, and they are essentially free (most are Open Source).

If the application requires high end graphics and Internet-based services, and power and heat aren't a factor, the industrial user can continue to reap the benefits of the COTS spiral and continue to "chase Wintel." But there is no reason to upgrade just because the spiral continues. Probably 50% of industrial control applications would run fine on a military-grade 80486-type device using the DOS operating system.

The COTS revolution has provided great benefits, including the ability to step off the spiral.

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