Future prospects for PC Control

# What could an Industrial PC with 32 GB RAM and a 64-core CPU achieve?

**When reflecting on the old days of room-sized computers and data punch cards, it's no secret that PC technology has developed rapidly over the decades. For more than 20 years, Beckhoff has promoted PC Control in industrial automation and the advances in this sector are also considerable. With a brief delay, the applicable technological developments from the "office PC world" eventually find their way into Industrial PCs. In this article, Beckhoff experts provide an overview of existing, current and future PC Control advancements.**


**Beckhoff delivered the first PC controller in 1986. How has automation software changed over the last 22 years?**

Andreas Thome, Product Manager PC Control: Rapidly, but also consistently. An important step was the introduction of the IEC 61131-3 programming standard as a versatile PLC programming language. This led to a certain degree of consolidation, and suppliers have become a little more comparable from the customer's perspective in terms of software features. Real-time capability within the respective operating system was and remains another key issue in the development of automation software. It is interesting to note that the world of automation implemented real-time capability robustly and reliably. Using Beckhoff as an example illustrates this clearly: The company managed to implement hard real-time with response times of 1 millisecond or less under all Microsoft operating systems, starting with DOS and followed by Windows 95/98, NT, 2000, XP and Vista.

Ramon Barth, Manager Software Development: Today, automation software has a significantly higher degree of abstraction than in 1986. This is supported by higher programming languages. Since the introduction of IEC 61131-3, Instruction List and Ladder Diagram are in retreat in terms of usage. A further trend is increasing modularization of the software with the aim of better reusability and maintenance. Advanced PC processors can easily satisfy higher computing power requirements. Thanks to PC technology, the integration of automation devices in IT networks is well advanced.

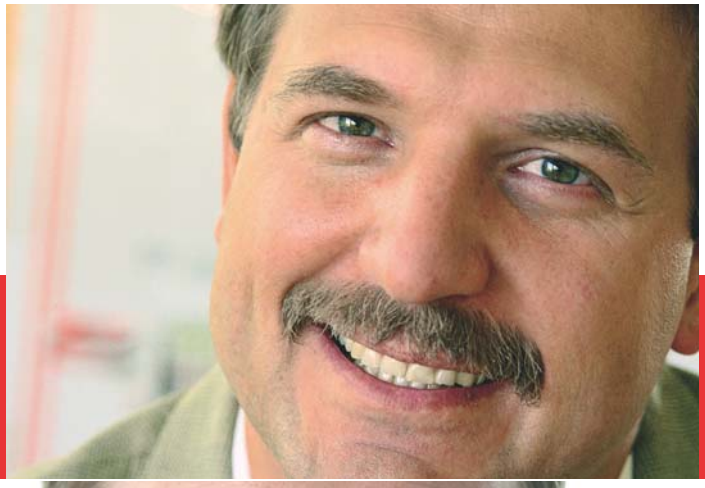
**How have Industrial PCs changed over the last 22 years? What is your vision for the future for a new generation of Industrial PCs?**

Roland van Mark, Marketing Manager Industrial PC: 20 years ago large, clunky and heavy PCs were installed on mounting arms directly at the machine or in housings, because PCs and displays were inextricably linked. Beckhoff was the first manufacturer 10 years ago to introduce displays with CP-Link, which enabled distances of up to 100 m from the PC. The PC can be installed in the control cabinet; two coaxial cables lead to the CP-Link Control Panel, a slimline, elegant control device with a depth of only 3 cm that is installed at the machine operator's workstation. The increasing complexity of applications led to an increase in the number of fieldbus cards and data cables connected to PCs. Over recent years, Beckhoff responded to this trend with different IPCs and now offers a wide range of devices – in other words, the right PC for almost any application.

One example for a new generation of IPCs is the CP72xx IP 65 Panel PC from Beckhoff. It offers machine operators a compact Panel PC that can be optimally positioned at the machine. Only two or three Ethernet cables and the power supply run through the mounting arm. No space is required in the control cabinet for PC installation. For large machines, additional control units can be installed as Ethernet Control Panels.

Existing Industrial PCs are also continuously optimized: Every year new, high-performance processors find their way into all Industrial PCs of our comprehensive product range. Time and again we develop additional PC designs that open up new application areas. PCs are becoming smaller and smaller thanks to energy-saving processors, more integrated moth-

Andreas Thome, Product Manager PC Control



Ramon Barth, Manager Software Development

Roland van Mark, Marketing Manager Industrial PC

erboards, elimination of plug-in cards and the application of Compact Flash as data storage.

**What is your vision for the future for a new generation of Industrial PCs/Embedded PCs?**

Andreas Thome: The focus is on developments offering high-performance processors with minimum heat output. The forthcoming Intel products – particularly the Intel® Atom™ processors (Menlow platform with Silverthorne CPU and Poulsbo chipset) – enable a further change in the power density of Industrial PCs. Plenty of computing power within the minimum footprint – this inspires the imagination of engineers and designers, and it will be interesting to see what new form factors they come up with. A hot topic for Embedded PCs is fanless design in view of rising processor power. For Industrial PCs, I expect increasing consolidation of display and computing units, since the PC as a smaller and smaller accessory will no longer be the determining element for device design but rather act as an "add-on" for the display. Moreover, I wouldn't be surprised if PCs began to be used in power controllers for motors or individual machine components. This will once again raise the issue of centralized versus local control technology. The further miniaturization of processors progresses, the more topical the issue of local intelligence will become. In turn, this will require more powerful development tools for controlling and programming a complex system consisting of many individual CPUs. As a result, the programming standards in the automation technology will have to develop further towards distributed systems.

## Industrial multi-core

**What effects do dual- and multi-core processors have on new control architectures?**

Ramon Barth: The high computing power of PC controllers enables the creation of software-based automation solutions that in the past required dedicated hardware components. Multi-core processors will reinforce this trend further, since processor-intensive fast algorithms will be able to use one of the cores exclusively.

Andreas Thome: Currently in automation technology, it is mainly the operating system that benefits from dual- and quad-core technology. Immediate benefits for the user arise from faster visualization software, which runs smoothly despite simultaneously operating real-time automation and offers fast image switching cycles and 3-D graphics. For the future, however, this is not sufficient. Automation software can also be distributed to individual cores in order to run several tasks simultaneously within the overall system, for example.

**Since Beckhoff develops its own motherboards it can quickly respond to new processors or chipsets. What developments are to be expected over the next few years?**

Andreas Thome: Beckhoff expects developments to go in two directions: On the one hand, support for new processors with low thermal output

Uwe Prüßmeier, Product Manager I/O Systems

(keyword: Intel® Menlow platform); on the other hand, implementation of the latest multi-core technology, e.g. Intel® Core™2 Quad processors. In this way, continuity and performance increases for all Beckhoff products are guaranteed. A further form factor in addition to ATX, Slot, 3½", Compact and PC/104 will be COMExpress. Custom designs will also be available for the new processor family on request.

## Communication

**What are the demands of PC-based control technology for the fieldbus or communication system?**

**Uwe Prüßmeier, Product Manager I/O Systems:** PC-based control technology vastly differs from standard, PLC-based control technology in terms of hardware performance. By integrating new and more powerful CPUs, the PC can be greatly enhanced with comparatively little effort. A wide range of available tools facilitate integration in other systems, and the human-machine interface is also much more user-friendly. This results in increasing bandwidth for the underlying bus system. More and more parameters and interfaces are transferred via the bus system, in parallel with the process data.

The computing power of a PC enables processing of larger and larger programs and data quantities. At the same time sensor technology supplies larger and larger data quantities, which also results in increasing bandwidth. Increasing CPU performance enables faster processing of programs. Computing algorithms are becoming more exact – with smaller dead time and smaller jitter. Positioning tasks can become up to ten times more precise if sampling takes place without jitter.

The communication system must be equivalent in performance. Larger control programs, and therefore more extensive I/O systems, require system-based diagnostics and maximum topology flexibility. The bus system should support any topology and be able to carry out automatic diagnostics for troubleshooting. – Redundancy is an important cornerstone for high availability in large systems.

**Which benefits does EtherCAT offer for PC-based control technology?**

**Uwe Prüßmeier:** EtherCAT satisfies the above requirements in an excellent manner. For the foreseeable future, the performance of EtherCAT is likely to be more than adequate, and its implementation represents an intelligent investment in the future. A wide range of equipment is already available today that offers users a future-proof, open and flexible interface with large reserve capacity for more than a decade.

**What cost benefits does EtherCAT have for machine construction and system engineering?**

**Uwe Prüßmeier:** EtherCAT offers customers a single bus system for all applications, with the advantages of lower storage and training costs. The large system reserve enables fast, simple and robust design of the communication solution. Because the system is topology-independent, practically no additional structural components are required. The fact that EtherCAT is so widely used offers a healthy competitive environment between similar suppliers and helps avoid a high-price policy for third-party EtherCAT devices. In addition to the price advantages for the individual I/O components, the elimination of a special fieldbus master card and the cost-effective Ethernet cables and connectors offer further savings potential.

**How does XFC technology contribute to higher energy efficiency?**

**Uwe Prüßmeier:** XFC – eXtreme Fast Control Technology – is based on an optimised control and communication architecture comprised of an Industrial PC, ultra-fast I/O terminals, EtherCAT and TwinCAT. With XFC it is possible to achieve I/O response times ≤ 100 µs and jitter in the reaction time << 1µs. This technology opens up new process optimization options for the user that were not possible previously with traditional components.

By reducing the cycle and response times, tolerances are reduced. As a result, product quality increases. Furthermore, more exact control also means that fewer defective products are produced.

Josef Papenfort, Product Manager TwinCAT

By means of very short reaction times, XFC reduces the times in which the machine is "waiting" for the controller. In this way, the same machine can produce more with greater precision. In addition, energy consumption is significantly reduced, because a machine requires additional energy in waiting mode. The savings range from a few percent to double-digit percentages. At the same time, the energy use for production is reduced, since XFC enables the same quantities to be produced with fewer machines. In turn, less production floor space is required, leading to even greater savings potential.

In servo systems XFC reduces motor losses, since the set values are output more exactly. The motor operates quieter and generates fewer losses; and the mechanical system is subject to less wear.

**Do today's communication systems still have room for innovations?**

**Uwe Prüßmeier:** From a technical perspective, there is always room for new innovations. The only issue is cost-effectiveness. As long as an existing design can be adapted to technical progress through continuous development – while safeguarding the compatibility of the installed base – new development can be too expensive, particularly from a user perspective.

Ethernet-based solutions will continue to benefit from further development in office applications, just like PC technology has done for years. In this way, transfer rates can be increased further without high costs. Over the next few years, there will be no leeway for another system from an economics point of view.

**Does the continuously increasing integration density – with concurrent price erosion – not lead to a situation where everything can be solved locally in future?**

**Uwe Prüßmeier:** Certainly not. Better price/performance ratio leads to more local functionality in the sensor and actuator and therefore to more quality and functionality. However, this also leads to more data with increased data processing requirements for continuous communication. Developing an integrated solution from all these components requires

## Scientific automation: integration of measurement technology into software PLC

**How are functions, such as measurement technology, image processing and robotics, generally handled today?**

**Josef Papenfort, Product Manager TwinCAT:** Today, special functions for measurement technology, image processing and robotics are usually handled in separate CPUs. The functionality is either distributed in the field or managed in the PC via plug-in cards. Only the concentrated data are transferred to the central control system. Preprocessing takes place in 'black boxes' and generally cannot be modified.

**Which benefits does integration of these functions into PC Control offer?**

**Josef Papenfort:** If the special functions are realized in software, the programmer has opportunity for intervention. Special filters or controllers, for example, can be programmed by the user himself.

**How is PC-based measurement technology integrated in the overall Beckhoff automation concept?**

**Josef Papenfort:** Measurement technology is a key component of an automation system. Only integration in a CPU enables all functions of a measuring system to be utilized optimally. Many filters and controllers can already be used through PLC libraries. In addition, interfacing with commercial tools such as LabView or Matlab/Simulink is possible.

**Which specific products are already available today? Which further developments are planned?**

**Josef Papenfort:** Measured data can already be transported to the central PLC via the high-performance fieldbus. A number of PLC libraries with different filters and controllers are already available for this purpose and are utilized intensively by customers. In the future we will offer even better integration with tools such as LabView and Matlab/Simulink.

**What is your vision for the future for PC-based measurement technology?**

**Josef Papenfort:** One aspect is optimal utilization of EtherCAT in order to feed measurement readings into the PLC quickly and with exact timestamps. The EtherCAT distributed clock feature is a key component for achieving this. In addition, libraries with digital filters and controllers must be available and – based on these – familiar and reliable measuring and control products must be integrated more closely.

linking of all data. The control solution could be distributed or local, although the user must be able to set up and maintain such an interwoven network. In my view this is best done based on a central device that enables reliable debugging, checking and revision. With a local solution the communication effort is comparatively more complex than with a centralized one. Backup of all parameters and programs with a central PC is a proven procedure that is easy to handle.

## Future of Automation

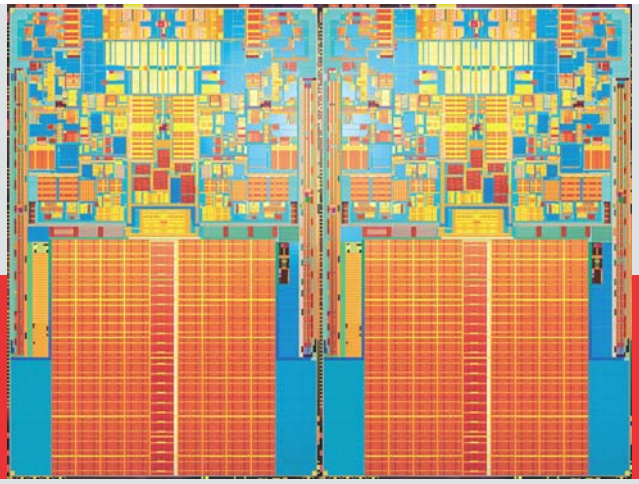
**What could an Industrial PC with 32 GB RAM and a 64-core CPU achieve?**

**Josef Papenfort:** The IPC will no doubt continue to do what it already does at Beckhoff, i.e. running I/O, PLC and Motion Control on a single device. A trend in moving to more and more complex PLC programs is already apparent. Cycle times are becoming shorter and shorter. The number of axes to be controlled synchronously will increase, and the type of coupling between the axes will become more complex. Electronic cam plates and gearing will also increase. In the future, many axes will be operated based on interpolation. However, in a few years' time, an advanced CPU will easily be able to cope with this. Integrated vision and robot systems will no doubt be possible in software. With sufficient CPU power, advanced and familiar control algorithms – such as neural networks – may become suitable for industrial applications. More complex machines require more diagnostics and maintenance. Expert systems and sophisticated diagnostics will make life easier for the end user. New input and output options such as voice input, for example, will simplify machine operation.

**Uwe Prüßmeier:** "Faster, higher, further" is always possible, although it should not be an end in itself. Higher performance must offer users clear benefits. Initially higher performance is not likely to be associated with rising costs. The main question therefore is: "What do we do with it?" General requirements are simplification of the operation, improvement of the integration in other systems and optimization of visualization. Improvement opportunities also exist for control tasks: Faster program execution, shorter cycle times, forward-looking maintenance and improved diagnostics. Online quality control of the production processes may also become possible.

**Andreas Thome:** Starting from the early days of PC technology people have dreamed of AI – artificial intelligence. Unfortunately, no intelligence that can match human intelligence has been created to-date, although in the future, this dream might come closer to reality through multi-core systems and brute computing force. In future computer generations, gesture, voice and image recognition procedures will be able to access terabytes of local data and at least provide support as sophisticated expert systems. In industry (and elsewhere) this can be used for improving process operation, more human interaction, faster troubleshooting and product quality checks. Each system component or machine module could be allocated to a core, so that parallel processing with high clock frequencies might become possible. However, experience over recent decades indicates that sudden technological developments – simply on the basis of faster computers – are not to be expected: Many applications will become faster and better; and this in turn will lead to a wide range of new options. After all, who would have thought a few years ago that a small GPS 'box' could show us the way, offer voice directions and at the same time provide commentary on places of interest?

Sebastian Richter, Field Application Engineer at Intel GmbH in Germany



Quad-core processor based on 45 nm technology from Intel

**At Hannover Fair 2008, Intel is a co-exhibitor at the Beckhoff PC Control booth. What made you decide to participate and what will Intel be exhibiting?**

Intel regards the embedded market as a growth area that is strongly shaped by automation technology. Beckhoff Automation offers an ideal platform for presenting Intel technology in the embedded sector.

We will show the benefits of dual- and multi-core processor technology in PC Control, explain the wide range of Intel solutions, including software tools and one-chip solutions, and offer visitors insights into future 45 nm technology developments.

**Which processor technology trends led to the development of multi-core processors?**

Miniaturization of the internal feature size (from 90 nm to 65 nm and 45 nm) enables Intel to integrate several processor cores into a single chip. In this way, we can increase the performance of the processors, and at the same time, their energy efficiency. With the introduction of 45 nm High-k based transistors, for example, we were able to reduce the power consumption by 50 % compared with the previous generation, or increase performance by 38 % with the same power consumption. In addition, our advanced software tools enable our customers to utilize the new options outside the server arena through parallelization.

**What general advantages do dual- and multi-core processors have compared with single-core processors?**

As soon as the software is able to operate in parallel mode, dual-core processors offer users significantly higher performance than their single-core counterparts. In addition, a multi-core configuration enables optimal utilization of platform technologies such as virtualization and execution of separate applications and/or operating systems.

In a recent article (PC Control 03/2007) Beckhoff described how a dual-core CPU enhanced the real-time capability of the system without additional power consumption. The multi-core CPU helped minimize latency periods.

**Beckhoff uses embedded processors from Intel for the company's Industrial PCs and Embedded PCs. What are the differences of the embedded versions compared to the desktop and notebook processors?**

The embedded group within our product range guarantees availability of selected processors from the desktop and notebook roadmap for a minimum of seven years. This enables our customers to be successful in embedded markets with lifecycles that are many times longer than those in the consumer PC market.

**At the Embedded World fair in February 2008, Intel presented embedded processors based on 45 nm HKMG semiconductor technology. Which processors are available with this technology, and for which applications were they developed?**

All Intel 45 nm-based processors already use High-k transistors. This development enables us to offer platforms that set new performance standards in the high-end range without an increase in power consumption, and to develop systems together with our customers for Embedded PCs such as the Beckhoff CX series and other miniature types.

**Is a 64-core CPU a utopian dream, or do you expect such multi-core processors to be available in the future?**

There is a clear trend towards multi-core. As a leading manufacturer, Intel already presented an 80-core chip referred to as Polaris with the power consumption of today's dual core processors. Even though this is still a research project, it nevertheless indicates the need for our customers to prepare their software for multi-core technology.

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