Many-core control: Automation technology with endless possibilities

Automation technology functions are determined more and more with software. In addition to pure PLC applications, tasks from the areas of motion and safety control, robotics and measurement technology are increasingly integrated into the application. More software also requires increased CPU power. With the new C6670, Beckhoff has unveiled the ultimate many-core industrial server, able to run the world's largest automation applications.

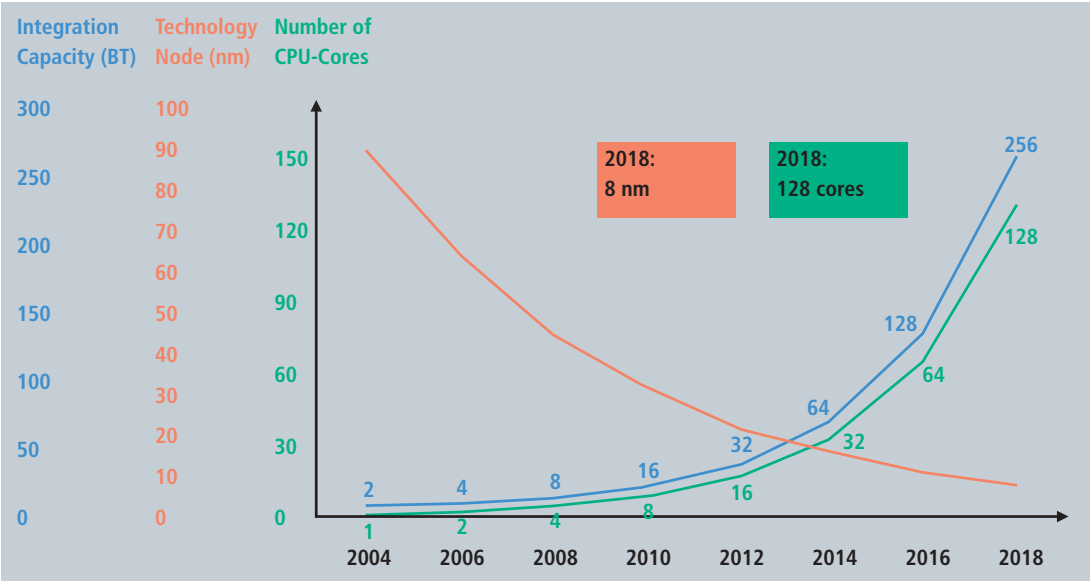
Many-core industrial servers

According to Moore's Law, CPU performance doubles every two years. This trend will continue to apply in the foreseeable future. Although processor speed will not increase significantly, the number of cores per processor will continue to rise.

The next step is the many-core CPU. Many-core industrial servers differ from 'normal' Industrial PCs (IPCs) in terms of their architecture. They are equipped with multiple processors, referred to as "packages", and each processor has a certain number of cores. Furthermore, many-core industrial servers differ in terms of their memory: the technology referred to as NUMA (Non Unified Memory Architecture) offers a separate individual memory unit for each processor. Currently, Beckhoff offers two Intel® Xeon® processors, each with 6, 12 or even 18 cores, integrated on one motherboard. Of course, the new many-core PCs are industrially compatible and can be mounted in the control cabinet.

Making full use of TwinCAT 3 performance

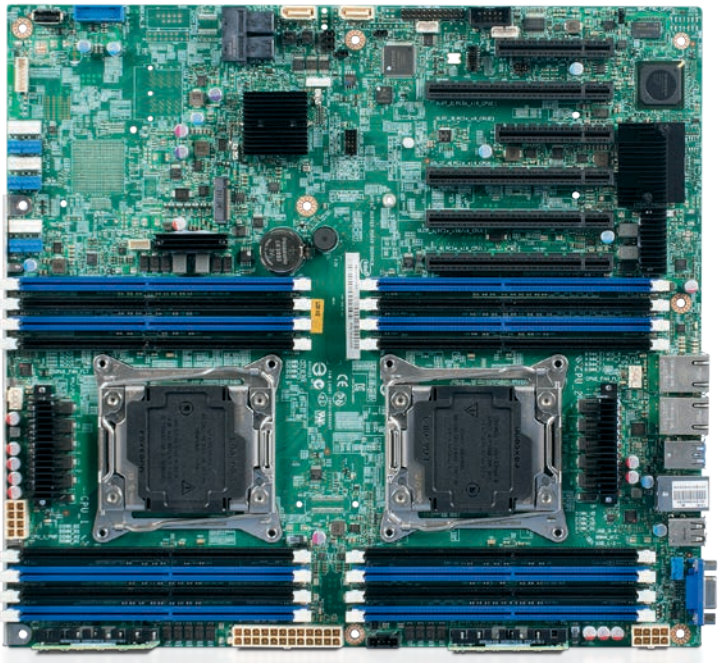
One can never have enough performance. Even now, machines and equipment that 10 years ago were still adequately equipped with a Pentium 3 are now powered by Core i7 processors. An ever increasing degree of automation, with more



Estimated development of the core number in the future

and more elaborate visualization, leads to demand for higher computing power. Additional factors are new demands on modern machines, such as machine monitoring via Condition Monitoring and ever faster and more complex control algorithms to achieve appropriate process quality and thus product quality. Naturally, there is a drive to integrate these new requirements into the standard control, which in turn increases the demand for computing power and memory.

In order to achieve optimum utilization of the individual cores, setting and diagnostic functions must be made available that go beyond the allocation of tasks to cores. TwinCAT 3 offers both aspects. In addition, TwinCAT 3 also offers the possibility to use cores exclusively for the TwinCAT runtime. These so-called 'isolated cores' no longer run a Microsoft operating system. In this way, it is easily possible to separate the Windows processes from the real-time processes on a PC.

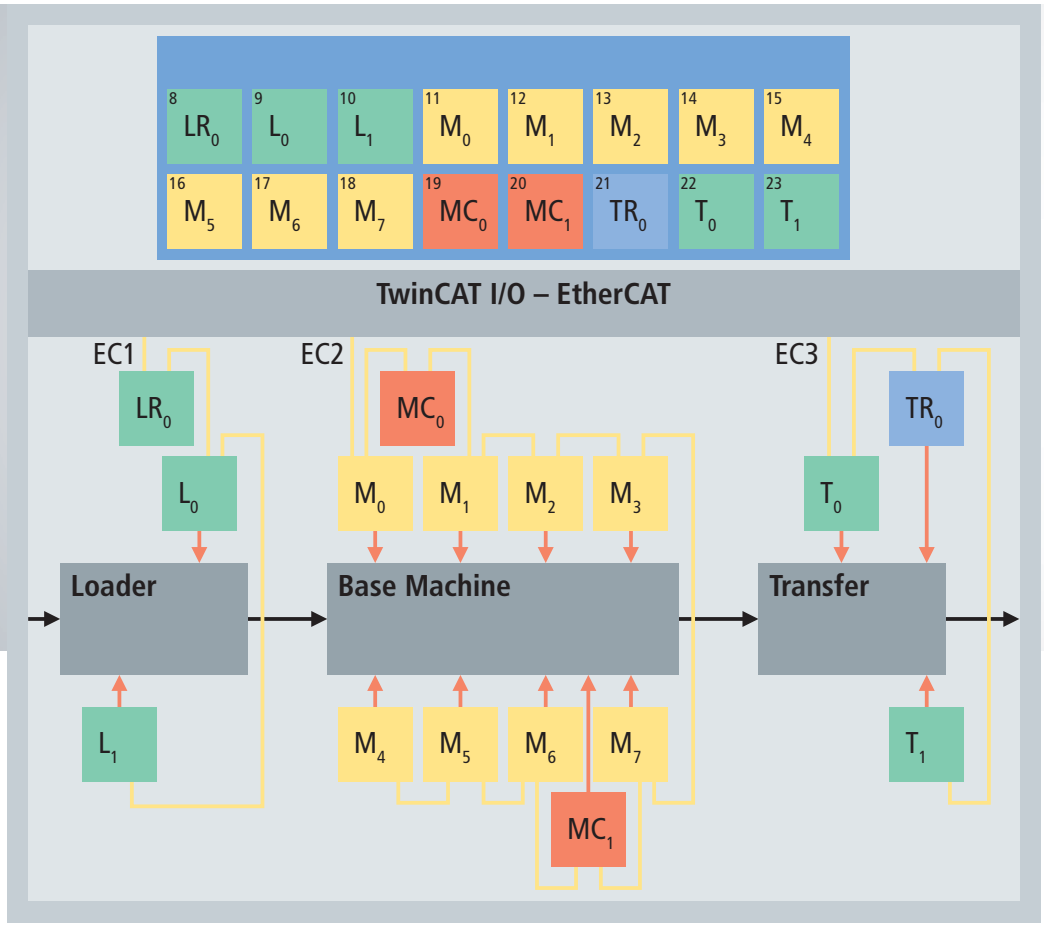


The C6670 industrial server already contains two Intel® Xeon® processors, each with 6, 12, or 18 cores, on one motherboard.

Possible fields of application for many-core industrial servers

Let's use an example to illustrate how the different cores of a many-core industrial server can be used. The example machine consists of three basic units: a 'loader', which loads the parts to be processed into the machine. Various modules (L_0, L_1 and LR_0) are used in the example. The module LR_0 is a loading robot. The basic machine for the actual parts processing also consists of different modules (M_0 to M_7, plus the CNC modules MC_0/MC_1). The manufactured components are then made available in a transfer unit for further processing. In addition to the T_0 and T_1 modules, e.g. for controlling of conveyor belts, a robot TR_0 is used here. One could distribute everything to many Industrial PCs. However, this would result in more communication overhead between the processors. In addition, diagnostics becomes more difficult, because the distributed data would have to be collected first. The software that runs on the different processors has to be managed, and interfaces have to be agreed. A powerful PC can be used to realize centralized control, while still leaving reserves for further expansion.

The different modules can be distributed to the individual cores of the many-core CPU, for example. In this way, the modularity is maintained, while the benefits of central controller can also be used. With this control philosophy it is



Machines and production facilities consist of different function modules, which lend themselves to mapping via individual control programs running in parallel, i.e. a many-core architecture.

possible – today and in the future – to implement each of the different modular machine parts on a central PC-based controller.

Naturally, a high-performance CPU can also handle a visualization. In some cases it may not be necessary to use intelligent Panel PCs, and a passive Panel may suffice. This saves money and reduces the component variety. Since many-core CPUs can be equipped with high-performance graphics cards, they can also be used to execute advanced and ergonomic 3D or multi-touch applications with high performance. The easy integration of wearable devices is another advantage.

Functionality increases with computing power

Besides the possibility to run one or more PLCs in IEC 61131 with object-oriented extensions, motion control with point-to-point axes (PTP) is also integrated. A CNC or a robot can also be enabled quite easily. The eXtended Transport System (XTS) also benefits from high computing power. With a corresponding number of processor cores, the possibilities are endless.

Machine performance improvements can be achieved with eXtreme Fast Control (XFC) technology from Beckhoff. It goes without saying that, in this case, more computing power is required. This is also true for image processing and condition monitoring. Both require a large memory area and a variety of complex algorithms. For the many-core industrial server, this is not a problem. In the future, simulations will become much more important in automation engineering. A first step was taken with the integration of MATLAB®/Simulink® into TwinCAT 3.

In addition to all these features, there will still be reserves for new ideas and for further performance improvements.

Performance enhancements through the use of many-core industrial servers

Thanks to increasing PC performance and the application of more and more processors and cores in many-core industrial servers, it is not only possible to accommodate dramatically increased functionality on a single central computer, the overall performance also increases continuously. Increasing computing power also allows task cycle times to be reduced considerably. Conventional PLCs have cycle times of 5 – 10 ms, while PC-based controllers with cycle times of 1 ms or less have already been available for quite some time. With high-performance many-core computers and TwinCAT 3 software, cycle times are expected to fall to a level of 100 µs or less. In addition to suitable software to support these short cycle times, a high-performance fieldbus is required. EtherCAT is perfectly suited to get data into the central PC deterministically and with exceptionally precise timing, even with high clock rates.

Based on XFC technology, which consists of a powerful PC (for example, a many-core industrial server such as the C6670), EtherCAT as the fieldbus, TwinCAT

Dr.-Ing. Josef Papenfort,
TwinCAT Product Manager,
Beckhoff

as a solution for PLC, motion and Scientific Automation, and particularly fast I/O modules, it is possible to achieve extremely fast response times of less than 100 µs. XFC enables higher sampling rates for control loops, which usually leads to better control results automatically. In more conventional applications, such as control of a pneumatic cylinder – which occurs dozens of times on machines, faster response times can also enhance the overall machine performance. All this comes about with minimum effort: simply reduce the cycle time and use special I/O components.

Summary

PC-based control technology has always benefited from increasing PC performance, coupled with steadily falling component costs. In today's PCs, the primary way to achieve higher performance is to increase the number of cores. Many-core industrial servers – such as the C6670 – feature a higher number of processors and at the same time more cores on a board. Currently, configurations with up to 24 cores are available. This is supplemented by a much larger cache and high clock rates.

Many-core industrial servers are capable of controlling complex machinery and equipment centrally. The performance of these computers is sufficient to run tasks in the fields of Scientific Automation and simulation in addition to conventional control tasks. Measurement technology, condition monitoring, energy monitoring, and many other functions can be implemented right alongside. And that's not all: high-performance many-core industrial servers can also handle advanced and ergonomic human-machine interfaces. Operating concepts such as wearable devices are integrated very easily.

If the many-core industrial server is equipped with eXtreme Fast Control, the performance of current machines can be improved significantly. In addition to shorter cycle times, there are many options for meaningful machine optimization.

Further information:
www.beckhoff.com/many-core-control
www.beckhoff.com/TwinCAT3