Industry 4.0: PC-based control concept as the core technology for the Smart Factory

PC Control has always been based on the convergence of information and automation technologies

PC-based control technology from Beckhoff offers the ideal toolbox for Industry 4.0 concepts. It opens the door to new ways of implementing visionary ideas ranging from cloud computing to social automation today. In this interview, Dr. Ursula Frank and Dr. Josef Papenfort explain which basic technologies, functions and services are already available and where additional developments are still needed.

The purpose of Germany's "Industry 4.0" initiative is to strengthen the competitiveness of the country's industries by improving flexibility, efficiency and sustainability in manufacturing through communication and intelligent controls. How can PC-based control technology contribute to this effort?

Dr. Josef Papenfort: At the core of Industry 4.0 is the convergence of information (IT) and automation technologies (AT), for which Beckhoff set the foundation over 25 years ago and continues to offer the best solution for future concepts. By employing global IT standards, we enrich automation technology with the best solutions the IT world has to offer. This also applies to our TwinCAT 3 automation software, which features the modularity and object orientation needed to realize Industry 4.0 concepts. In addition, the integration of TwinCAT 3 into Microsoft Visual Studio® provides the ideal basis for consistent engineering across the entire product lifecycle with the latest software engineering tools from the IT world. With the PC as the accepted platform in combination with the Automation Device Specification (ADS), the EtherCAT Automation Protocol (EAP) and the OPC Unified Architecture (OPC UA), Beckhoff has all the tools users need for implementing the vertical and horizontal integration required for Industry 4.0.

Dr. Ursula Frank: On the one hand, Beckhoff supplies the basic technologies for implementing intelligent production facilities and smart factories in accordance with the Industry 4.0 concept. On the other hand, it is becoming increasingly important – particularly in connection with the Industry 4.0 concept – that the systems operate not only efficiently, but safely and reliably. This is where the concept of "Scientific Automation" offers huge potential with its integrated measurement technology and Condition Monitoring up to the monitoring of complex production systems. To explain, Scientific Automation involves the integration of scientific findings from various disciplines into automation technology so that we can build more reliable and energy-efficient production systems with inherently intelligent features. This will also require new, intuitive operator interface concepts that make it easier for humans to perform their everyday work and interact more effectively with intelligent machines. After all, Industry 4.0 is not intended to push the human element aside. Our multi-touch-capable industrial panels make these new operating concepts possible.

Is Industry 4.0 already being implemented in real-life applications? What additional developments are needed, if any?

Dr. Ursula Frank: There are already many end users such as large kitchen manufacturers who automate entire systems from receiving to shipping with Beckhoff technology, including their integration into their ERP systems. Some initial solutions are definitely in line with the Industry 4.0 concept, for example, by providing continuous communication across all levels with some approaches to an intelligent production environment. It goes without saying that we will continue developing our products and our portfolio in this direction over the coming years.

Dr. Josef Papenfort: As part of TwinCAT 3, for example, we are working on improved engineering functions by providing additional features like easier communication capabilities and configurations. Also important in this context is the continuing development of universal communication standards such as those

Beckhoff experts Dr. Ursula Frank (Project Manager R&D Cooperations) and Dr. Josef Papenfort (TwinCAT Product Manager) believe that PC Control already provides an ideal toolbox for Industry 4.0 concepts today.

being defined by the OPC Foundation and the PLCopen Association. Beckhoff is actively involved in both of these standardization efforts. One of the goals is to not only exchange data with the ERP system via OPC UA or ADS, but to also be able to call up and execute methods directly in the PLC. This would be the next step in the evolution of communication.

How important is the openness of PC Control for the "Internet of Things"?

Dr. Ursula Frank: It is very important. Put in very abstract terms, the Internet of Things implies that products as well as systems and their modules can communicate openly with each other. This is precisely what the open control technology from Beckhoff makes possible by allowing the developer to design the system with the ability to function and communicate intelligently.

Dr. Josef Papenfort: The open interfaces represent a significant advantage of PC Control. This applies to engineering applications and as to the fieldbus technology being used as well as to the components being integrated such as RFID chips or intelligent sensors.

Does this openness also apply to the automation architecture as a centralized or decentralized system?

Dr. Josef Papenfort: Of course it does. As a rule, we prefer the centralized approach, because it has advantages in the areas of engineering, data administration and diagnostics. But there are also certain systems such as assembly machines where a decentralized approach may work better. For example, such a solution makes it easy to replace individual modules, because the central control components must only be adapted to the new work station. In addition, systems or machines on the production floor don't operate as islands, but are usually networked – a trend that will accelerate significantly in connection with Industry 4.0. Accordingly, each machine is controlled locally in a larger system or an Industry 4.0 concept. A very important factor in this approach is the implementation on the software side, which we support with modular programming via TwinCAT. After all, it doesn't matter whether 10 software modules run on a central CPU or individually on 10 different controllers. How the data traffic is executed between the modules – whether on a local PC or via EAP which is equally deterministic and fast – also doesn't matter. PC Control makes it easy to implement either version depending on the application requirements.

The vision of Industry 4.0 even extends to something referred to as the "Facebook of machines" or "social automation." What does this actually mean?

Dr. Ursula Frank: The vision of social automation involves transferring the new developments in information and communication technology to industrial applications. As we mentioned earlier, linking information and automation technologies with PC-based control technology is at the core of technology from Beckhoff. Accordingly, Beckhoff will always take a close look at the latest developments in information technology with regard to their use in automation technology. Trends like social media, for example, may offer new communication capabilities. We must check what potential benefits may arise from using these communication capabilities in the automation field. The "Facebook of machines" is one such scenario. For example, users can create individual

Dr. Ursula Frank: "At this year's Hannover Messe we will show as part of our Industry 4.0 Forum that open, PC-based control technology from Beckhoff already makes it possible today to seamlessly integrate production systems and modules into existing and new production systems – and have them communicate with higher-level production scheduling and control levels. To fully support the Industry 4.0 concept, however, a lot of research and development will still be needed over the coming years."

profiles on Facebook, describe their lives on the "timeline" and offer information or services on their "wall." Transferred to industrial applications, this would mean, for example, that a machine may post its current utilization or offer its services on a similar wall. If it does not have the requested capacity, it could refer the interested party to a "friend" in the corresponding "Facebook machine group." Another option would be to adapt the traffic backup information on Internet services like Google Maps or TomTom to the world of industrial production. This would enable you to monitor a factory's machine utilization rates or even generate duty rosters for machines via a Doodle survey.

Dr. Josef Papenfort: We are again coming back to the convergence of information and automation technology within the framework of PC Control. Just as we combined our automation know-how with the Visual Studio® IT engineering tool to create TwinCAT 3, the next step might involve enriching Internet services like Facebook, Doodle or WhatsApp with automation features. Another approach has already been implemented by Beckhoff with a technology study that proved that Google Glass as a "wearable device" can significantly simplify human-machine interaction, for activities involving commissioning and fault diagnostics, for example. Functions like the retrieval of online support information or troubleshooting with a specialist via video-based live chat make Google Glass an enabling technology for social automation.

What roles do hot current IT topics like cloud computing and big data play?

Dr. Ursula Frank: We will see more and more solutions in the future where data and parameters reside in the cloud. At the end of the day, it doesn't really matter where the information is stored. Today and in the coming years, however, most of the data will still be processed in the machine or system. On the other hand, things like measurement data are already being stored in the cloud and analyzed offline in many cases. We will definitely see an increasing shift towards cloud computing. Over the long term there will surely be some Internet services that affect automation technology, for example, as a machine monitoring app.

Dr. Josef Papenfort: With regard to big data, i.e. large amounts of data from a wide range of sources, the focus is predominantly on the subject of data storage at this time. And the amount of data will surely increase even further, as a result of images and videos being stored for more thorough tracking-and-tracing applications, for example. On top of this we will see more offline analytics, and these will be performed increasingly as a cloud-based service. In the wind energy field, this approach has already been practiced for years. The service providers don't access the data on the turbine itself, but take it from the cloud to be analyzed offline.

Will we see more real-time services in this context?

Dr. Josef Papenfort: With more and more data being stored in the cloud, we will also see more real-time – or rather, deterministic – processing. With the IEEE 1588 protocol, such real-time services for machine synchronization are already being implemented. This synchronized collection of distributed data will become more and more prevalent, particularly in the area of measurement technology, but it will not replace the local control intelligence in the machine. Another aspect is more important: We already have technologies for analyzing data in real time, i.e. on its path to the cloud. These techniques might become widely accepted over the medium term in order to filter out the large amount of unimportant information before it gets stored.

Are such complex Industry 4.0 engineering concepts still manageable?

Dr. Josef Papenfort: Modern systems are becoming more and more complex, and the Industry 4.0 concept will only accelerate this trend. That's why we will have to pay more attention to efficient and reliable engineering in the future. We have already taken a great step in this direction with TwinCAT 3, which reduces the engineering effort with features like source code control and automatic code generation. Where I still see potential for improvement is in the efficiency of the data management, for example, by transferring the motor design data directly into the engineering system and making it available there without any additional effort.

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Dr. Ursula Frank: This is an area where a lot still needs to be done. From the engineering perspective, the data transmission between the various development domains, such between the control technology and E-CAD or M-CAD, is still not completely error-free and seamless. There are some approaches and solutions such as the AutomationML standard, but we don't have a standardized data pool at this time. TwinCAT has featured many open data export and import interfaces for some years now. The TwinCAT E-CAD import program makes use of these interfaces and can communicate directly with various E-CAD programs on the market. However, additional tools are still needed. For example, order data from an ERP system must be able to flow into the engineering level. What's most important, however, is that the data can be shared on all levels so that effective and synchronized engineering becomes possible across the entire life cycle.

Will simulation play a larger role in the engineering field as a result of Industry 4.0?

Dr. Ursula Frank: Industry 4.0 will make the systems more complex and more intelligent, but also less predictable. When machines are allowed to react on their own and negotiate with other machines, the human brain is no longer capable of predicting the overall behavior. That's why powerful simulation tools will be indispensable. This is a truly long-term vision, but ideally we would have tools that simulate not only the development concept but can drive simulations on their own.

Dr. Josef Papenfort: Such systems would reduce not only the commissioning time and costs. Simulation can support all areas such as the machine design process, electrical engineering and software development, because it will make it possible to test any changes quickly via the control technology and the software without having to make hardware modifications. Naturally, the corresponding interfaces for importing simulation models and providing the relevant data must be available. Today, TwinCAT 3 already offers features such as the integration of Matlab®/Simulink® models in real-time as well as the TwinCAT Simulation Manager for the easy configuration of a simulation environment.

What concrete results of the research activities for Industry 4.0 are already visible?

Dr. Ursula Frank: We are, for example, actively involved in the "it's OWL" (Intelligent Technical Systems OstWestfalenLippe) network, which the German Federal Ministry for Education and Research named a "Leading-Edge Cluster" in 2012 and is the first large Industry 4.0 project. We are working, among other things, on reference models, i.e. automation solutions for various classes of production systems that can be transferred to similar systems. In addition, the ScAut project, which focuses on a Scientific Automation platform for the development and operation of intelligent, self-optimizing machines and systems, is already bringing forth some concrete economic benefits. Depending on the application, Scientific Automation functions such as condition and power monitoring may produce energy savings of roughly 20 percent, productivity improvements of 10 percent and maintenance cost reductions of 50 percent.

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