PC-based building automation at the Fraunhofer IAO Center for Virtual Engineering

Open and flexible control technology facilitates innovative, efficient building implementation and design

The new Center for Virtual Engineering (ZVE) is designed to be as innovative as the research work conducted inside. The flexible, all-encompassing building automation system enables a myriad of possible uses and facilitates significant overall energy savings. The complex automation concept was implemented by Herrmann GmbH & Co. KG, system integrators who were able to react optimally to changes during the planning and construction phase by employing open control technology from Beckhoff.

The open atrium of the ZVE with its deliberately placed connecting stairs creates a close interrelationship between the different working levels and considerably reduces vertical communication barriers.

The Stuttgart, Germany-based Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO) [Institute of Industrial Engineering] deals with current issues regarding workplaces and the people that work there. The scientific knowledge of the IAO, particularly in the fields of virtual engineering and workspace innovation, flowed continuously – for example, as a digitized planning and building process, as well as 3D visualization in Virtual Reality – into the design of the Center for Virtual Engineering, which opened in June 2012. The building houses researchers and engineers from various disciplines who work on these technologies, as well as on innovative work and office concepts.

Modern building employs the latest and greatest in building services

The office and laboratory areas in the ZVE are arranged on four floors and cover over 3,200 m² around an open atrium, so the conventional strict separation of laboratory and office areas is eliminated. In fact, the primary functional areas of the scientific work – laboratory, office and meeting – are spatially interlocked so that walking distances are minimized, optimizing communication within the teams. The daily workplace is not a particular office or laboratory, but is selected at the time of use according to the current tasks and resource requirements. The further one gets from the open core of the building interior, the quieter it gets in the individual areas, in order to enable employees to concentrate on their work. In addition, the use of the office workstations becomes more flexible with each higher floor.

Just as cutting-edge as the building itself is the energy technology contained within, as Heinz Kühner, building officer of the Fraunhofer IAO for the ZVE project, explains: "Our energy concept is based on a geothermal system that employs several 170 meter long geothermal probes for the recovery of renewable energy from underneath the Earth's surface. This is supplemented by heat exchangers and ceilings with activated concrete cores for cooling and base load heating. In addition to water-filled pipes, there are also air-filled plastic balls in the ceilings. The hollow decks of the ceilings reduced the amount of concrete required and thus the static load in favor of larger spans and column-free spaces. The tank for the sprinkler system is used as energy storage for waste heat from the building, e.g. from the computer rooms or the high-performance projectors in the Virtual Reality laboratories."

Complete building automation exploits all available efficiency potential

The comprehensive building automation system leverages over 7,000 data points to control heating, cooling and ventilation, as well as light, shading, and individual room control according to current needs. In addition, an energy measurement and monitoring system analyzes the effects of these control measures. This creates an ideal base line to enable the most energy-efficient building operation possible. The success of the numerous innovative aspects installed within the building infrastructure – from noise insulation by means of absorption materials for low-frequency noise components, the control of the LED lighting technology, depending on occupancy, daylight and workplace, and the monitoring of the air quality by CO_2 concentration – is validated by the Gold Certificate of the Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB) [German Sustainable Building Council].

Moreover, the open, PC-based control technology from Beckhoff offers the advantage of very high flexibility, which is indispensable for the high demands

Eight CX5020 Embedded PCs are used as floor controllers in the ZVE.

of the ZVE, due to the wide diversity of the work areas. Martin Balb, head of building management at Fraunhofer IAO, explains: "Our concept of interlocked office areas extends from the classic cellular office and team offices to group offices and open office areas. One can bring the appropriate specialized groups or multidisciplinary teams together as required. Above all, it is important to react as quickly as possible to individual work requirements bringing together the right employees and the appropriate office functionalities." Michael Falkenstein, building automation team leader at the system integrator Herrmann, adds: "In order to successfully implement this level of flexibility in terms of building services, it was enormously important for restructuring to be possible at any time. Therefore, we entirely eliminated hardwiring. Two CX5020 Embedded PCs control all the functions on each floor. The I/O data points are connected and networked with BK9050 Ethernet Bus Couplers via corresponding Bus Terminals located in the wall cladding. The entire lighting technology is integrated flexibly by the bus system via the DALI standard. Therefore, no limits are imposed with regard to possible restructuring of control areas that would need to be adapted accordingly."

Open control system unites heterogeneous building systems

For Heinz Kühner, the main argument in favor of PC Control from Beckhoff was the openness of the system: "Due to the number of partner companies, it was clear during the planning phase that many different bus systems needed to be covered. PC Control, as an open control technology, has made this possible in an ideal way, being inexpensive and without complex special solutions. In addition, the system integrators at Herrmann not only have extensive backgrounds in building automation and control technology, but also many years of experience with Beckhoff technology."

This was an area in which Michael Falkenstein was able to apply his knowledge to a particularly large extent: "None of our previous projects needed so many different bus systems as had to be integrated into the ZVE building. For example, the proprietary and quite sophisticated bus for the electrically adjustable windows had to be integrated. We implemented this with a special LON gateway, which, in turn, was implemented simply into the Beckhoff system via the KL6401 LON Bus Terminal. Overall, the heterogeneous automation technology was very

The Center for Virtual Engineering in Stuttgart, Germany offers a highly modern environment for research into innovative workplaces and processes.

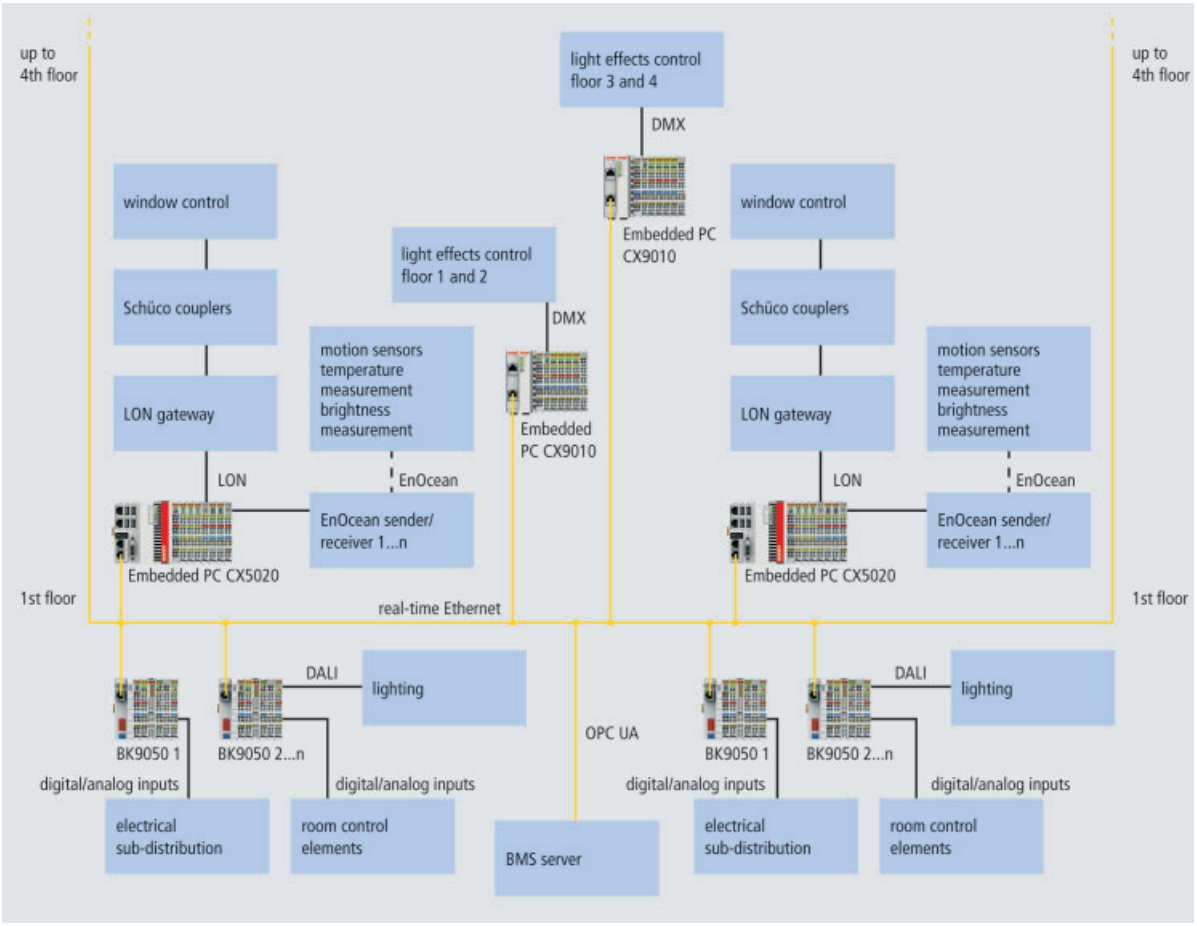
quickly and flexibly implemented with PC Control. The powerful System Manager in Beckhoff's TwinCAT software delivered numerous advantages, including facilitating a simple and efficient integration of the bus systems and even our own complex HVAC library. Such complex projects can typically only be implemented at reasonable expense when using the wide range of Bus Terminals from Beckhoff." The integration of media technology via the TwinCAT Crestron Server, which is also planned for the ZVE, has already proven viable in earlier projects. This is scheduled for implementation in the larger meeting rooms and the 3D interaction lab.

Martin Balb sees further advantages in the openness of the system: "There were also some changes in the continuous planning and building process due to technological advances. For example, LED lighting technology was not available in a practically usable form during the planning stages in 2006. With an open system such as PC Control, we were able to adapt to these dynamically changing requirements. Without it, all the bus systems would probably have had to run in parallel, with immense expenditure for installation, commissioning, and maintenance."

Complete PC-based measurement and control technology

System integrators Herrmann & Co. have implemented the complete measurement and control technology of the ZVE with PC Control, i.e. heating, ventilation, and cooling systems, as well as individual room control or lighting and shading. Eight CX5020 Embedded PCs are used as floor controllers, an additional four CX5020s as controllers for geothermal energy, heating/re-cooling, weather station and plant control, as well as two CX9010s for DMX floor control. A total of 56 BK9050 Ethernet TCP/IP Bus Couplers serve as data collectors for digital I/Os and window contacts, as well as EnOcean and DALI components. Two further BK9050s acquire the information from the electrical sub-distribution system. All these data are then stored on a server of the building management system (BMS), available to the plant management, the energy measuring system, and the web-based energy monitoring in "atvise", each of which was also implemented by Herrmann.

The communication systems employed are real-time Ethernet as the controller network, OPC UA for communication with the server and as the MBE network, DALI for the lighting control, EnOcean for the motion sensors and the temperature/brightness measurement, LON for the control of the windows and DMX for the control of lamps and light effects. Michael Falkenstein explains: "There are a relatively large number of controllers in operation in the ZVE that constantly communicate with one another. This results in a very high data volume, which can be easily handled by real-time Ethernet. In addition, we have been using this communication system for quite some time, and are therefore well-acquainted with its advantages. These include multicast functionality, reliability, and simple handling. The decision to use OPC UA was also an easy one to make, because only this protocol offered the necessary functionality for the integration of visualization and energy monitoring at the start of the planning. A further advantage was that the OPC UA variable is already directly instanced in all the function blocks for individual room control, which reduced the engineering work immensely."



Automation topology of a ZVE floor

From left to right: Michael Falkenstein, building automation team leader at Herrmann, Heinz Kühner, building officer of the Fraunhofer IAO, Oliver Heilig from the Beckhoff branch office in Balingen, Germany, and Martin Balb, head of building management at the Fraunhofer IAO, in front of a control cabinet for the HVAC equipment in the basement of the ZVE.

Automation enables comfortable and energy-efficient building operation

The CX5020 floor controllers handle the main tasks to ensure more energy-efficient building operation, i.e. individual room control, including light and shading control, as well as room conditioning and primary energy supply. At the same time, attention was paid not only to the minimization of energy requirements, but also to higher convenience in use. Thus, the rooms are optimally automated with occupancy sensors, as well as daylight and workplace-dependent lighting control. If necessary, the heat input of sunshine can be used to save energy by raising the external sun blinds; the internal glare protection prevents excessive window glare in the workplace. Furthermore, the building automation can control all windows in relation to the internal temperatures, for example, in order to air the building in the early morning during the summer months and thus achieve pleasantly cool temperatures at the start of working hours without additional cooling power required. The priority is always placed on the office user, who can then manually change the automatically preset values at the workplace as he or she desires.

Further information:

www.iao.fraunhofer.de
www.herrmann-leittechnik.com
www.beckhoff.com/building