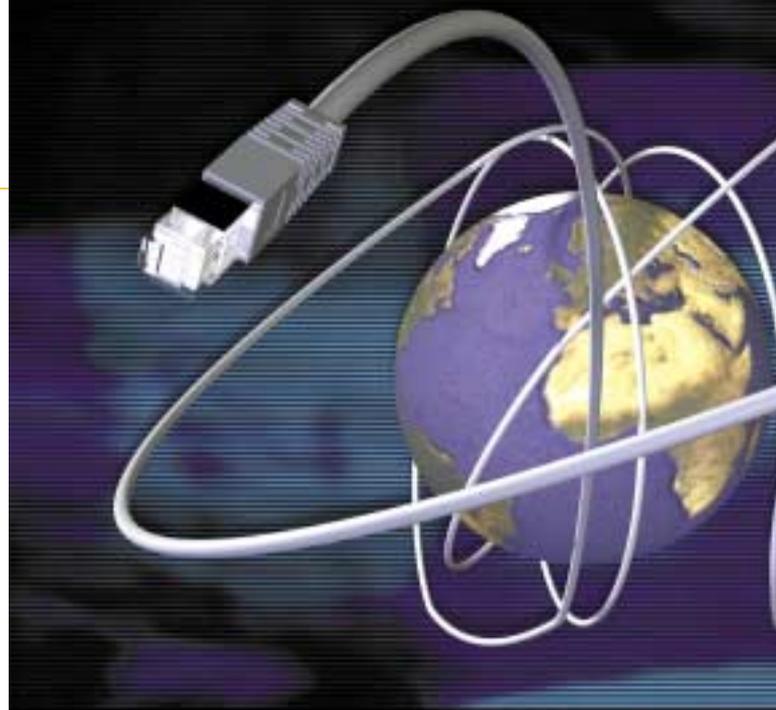*More and more machines and plant manufacturers use the advantages of Ethernet technology for industrial applications. The Ethernet standard is becoming established as an alternative to conventional fieldbus systems.*

Proven in industrial applications

Master functionality with compact design

Ralf Vienken*, Frank Metzner**

The application of Ethernet as a sensor/actuator bus is of particular interest where an Ethernet infrastructure already exists or is planned – e.g. in building automation, or generally in applications using PC-based control technology.

Following the successful application of Beckhoff Ethernet components, their range of applications and functionality has been expanded through continuous further development. Event-driven sending and receiving, extended IP address assigning options or sending of e-mail or SMS messages are now supported by the Bus Terminal Controller with Ethernet interface. For networking of controllers, Ethernet has been state of the art for some time - what is relatively

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new is the application of this technology as an I/O bus system. The Beckhoff Ethernet solution for I/O systems consists of the Bus Coupler and the Bus Terminal Controller. The Bus Terminal Controller additionally contains a logic controller for the Bus Terminal system. All common I/Os can thus be connected directly to the Ethernet: Up to 64 two-and four-channel Bus Terminals for digital, analog or special signals, such as serial interfaces, encoders or counter functions.

The BK9000 Bus Coupler is integrated into an Ethernet network as a slave with 10/100 MBit/s. The connection is via common RJ 45 plug connectors.

Based on the Bus Coupler, the BC9000 Bus Terminal Controller additionally has integrated PLC functionality. The Bus Terminal Controller is programmed via the TwinCAT programming environment according to IEC 61131-3. The program can be transmitted serially or via Ethernet.

Ethernet components: proven in practice

The Ethernet components from Beckhoff have proven themselves for about two years now in industrial applications in a variety of

industries and in many automation technology applications. In the automotive sector, Ford uses Bus Terminal Controllers at its plant in Genk, Belgium. A fast Ethernet backbone with 100Mbaud in full-duplex operation connects 130 Bus Terminal Controllers. These control a complex transportation system, which handles the clocked provision of components and systems from four suppliers.

In the Brazilian DaimlerChrysler factory at São Bernardo do Campo, the intelligent miniature controls from Beckhoff enable the exchange of information between the mechanical screw drivers of the individual assembly lines and the higher-level company network in a production line for small engines.

Building and office functions

The open and flexible Ethernet concept from Beckhoff is also increasingly used for building automation: For example, at Microsoft's European head office in Germany, around 12,000 data points are acquired via electronic Bus Terminals from over 200 BC9000 Ethernet Controllers for HVAC, security, access and other functions. In another project, the

Controllers, together with 3,000 intelligent Bus Terminals, control approximately 2,200 blinds in an extensive building complex. Since the Controllers exchange information amongst each other via Ethernet, no central PC is required.

In a distributed application at the university of Zurich in Switzerland, the access control for the individual buildings is managed centrally via a single computer. It is noteworthy that the university buildings are spread over the whole city, and the Bus Terminal Controllers are decentrally connected to the university network.

Another building automation project was realised at a steel plant in Bremen (Germany). The heating systems of various buildings at the 8 sqkm site are controlled by the intelligent Ethernet I/O periphery. It is planned to equip a total of 77 buildings with Bus Terminal Controllers.

Ethernet components are also used successfully in other industries such as processing machines, transportation equipment, logistics or the food industry - for example in a production management system at a

plant for bread, cakes and pastries.

Ethernet enables integrated communication solutions without technology discontinuities and provides economic solutions particularly in applications where the broad bandwidth of an existing Ethernet infrastructure can be used for I/O communication with moderate real-time requirements. During the development of the Beckhoff Ethernet modules, particular emphasis was therefore placed on complete compatibility with the IT architecture. The devices combine good performance with comprehensive functionality, enabling the seamless integration into existing networks.

Event-driven sending and receiving

New characteristics and further developments make the use of Ethernet components for industrial communication or for remote maintenance even more interesting. The active transmission of data via Ethernet is a function of increasing importance for communication in an Ethernet network. This implies a fast reaction to events. It is no longer necessary for the Ethernet Bus Terminal Controllers to be interrogated by a master; they only now need to transmit data when an event that requires a message has occurred. This significantly reduces the network load. Related to this is lateral communication between several Bus Terminal Controllers. This

functionality is implemented through function blocks in IEC 61131-3. Apart from the Automation Device Specification (ADS) developed by Beckhoff, the ModbusTCP protocols are supported:

Lateral communication via the ADS protocol

The ADS routing functionality enables communication via any connecting route: between tasks and software modules within the Beckhoff control world, between PCs via Ethernet, even via the most important fieldbusses directly to the distributed automation devices. Via ADS, the Bus Terminal Controllers can exchange data between themselves, send data to a PC or communicate with a BK9000 Bus Coupler. A BC9000 Controller can handle up to four IP sockets at the same time. This means that a BC9000 can communicate with four other devices

simultaneously. The IP sockets can also be opened and closed at runtime, in order to communicate with additional devices.

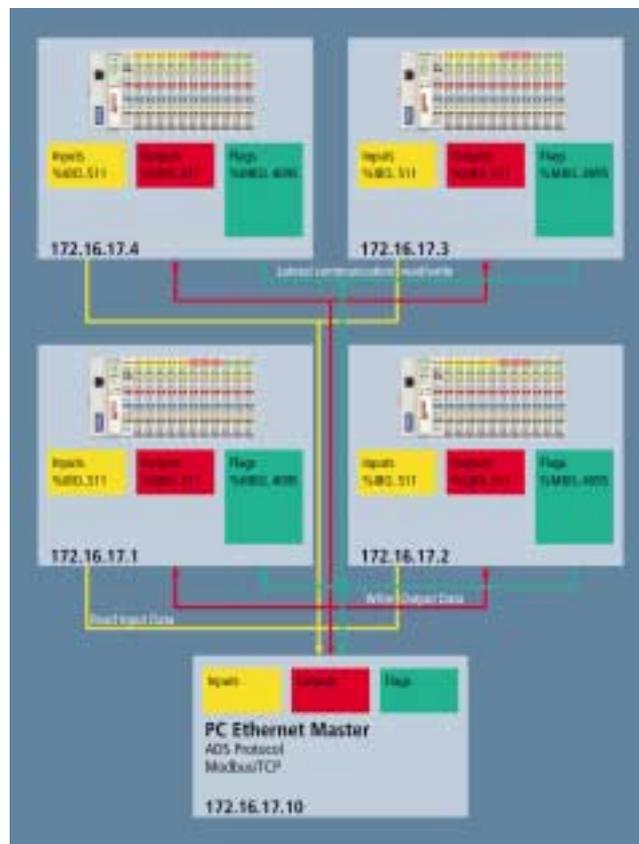### Lateral communication via ModbusTCP

The second implemented solution set is based on an open solution for ModbusTCP. A Modbus channel can be opened via a function block, in order to communicate actively with other ModbusTCP-Ethernet nodes. There are, again, up to four IP sockets available. The BC9000 comprises three process image areas for data communication. Read-only access via Ethernet is available for the 512-byte input process image. The output process image is triggered via a watchdog, i.e. after a selectable time the outputs will be changed to a safe state unless a new telegram has been received from a node within this watchdog time.

Only one device has write access at any one time; all other devices only have read access to the output process image. The third area is the flags process image. For BC9000, its size is 4 kB and offers a variety of options for sending and receiving of data and is ideally suited for lateral communication. There is no watchdog, so data can be sent to the Bus Terminal Controller when the application requires it, whether this is after seconds or after days. For Ethernet devices, like for others fieldbus modules, two basic communication settings are required: baud rate and node address. Beckhoff Ethernet devices detect the baud rate automatically.

In Ethernet networks, the IP address serves as the node address. There are four different ways in which it can be set or assigned. The Bus Couplers and Bus Terminal Controllers support all the normal methods for IP address assignment: via configuration software and DIP switch setting, via DHCP server or via ARP message. Another alternative is the Beckhoff BOOTP server for Windows operating systems, which recognises and addresses the Ethernet nodes automatically.

BC9000 sends e-mail or SMS

An e-mail function block has been implemented as an additional property in the BC9000 Bus Terminal Controller. The function is based on SMTP (Simple Mail Transfer Protocol). In combination with an e-mail server, it is now possible to send e-mails in order to report errors, diagnostic information, warnings or any other information. SMTP is an open standard for the Ethernet world. It is also possible to send SMS messages. A function block can be used, in combination with a GSM modem and a Bus Terminal acting as a RS232 gateway, to send an SMS in the event of fault directly to the mobile telephone of the plant operator or service technician.

The BC9000 Bus Terminal Controllers support active sending and receiving of data via Ethernet. This enables lateral communication independent of a higher-level master.