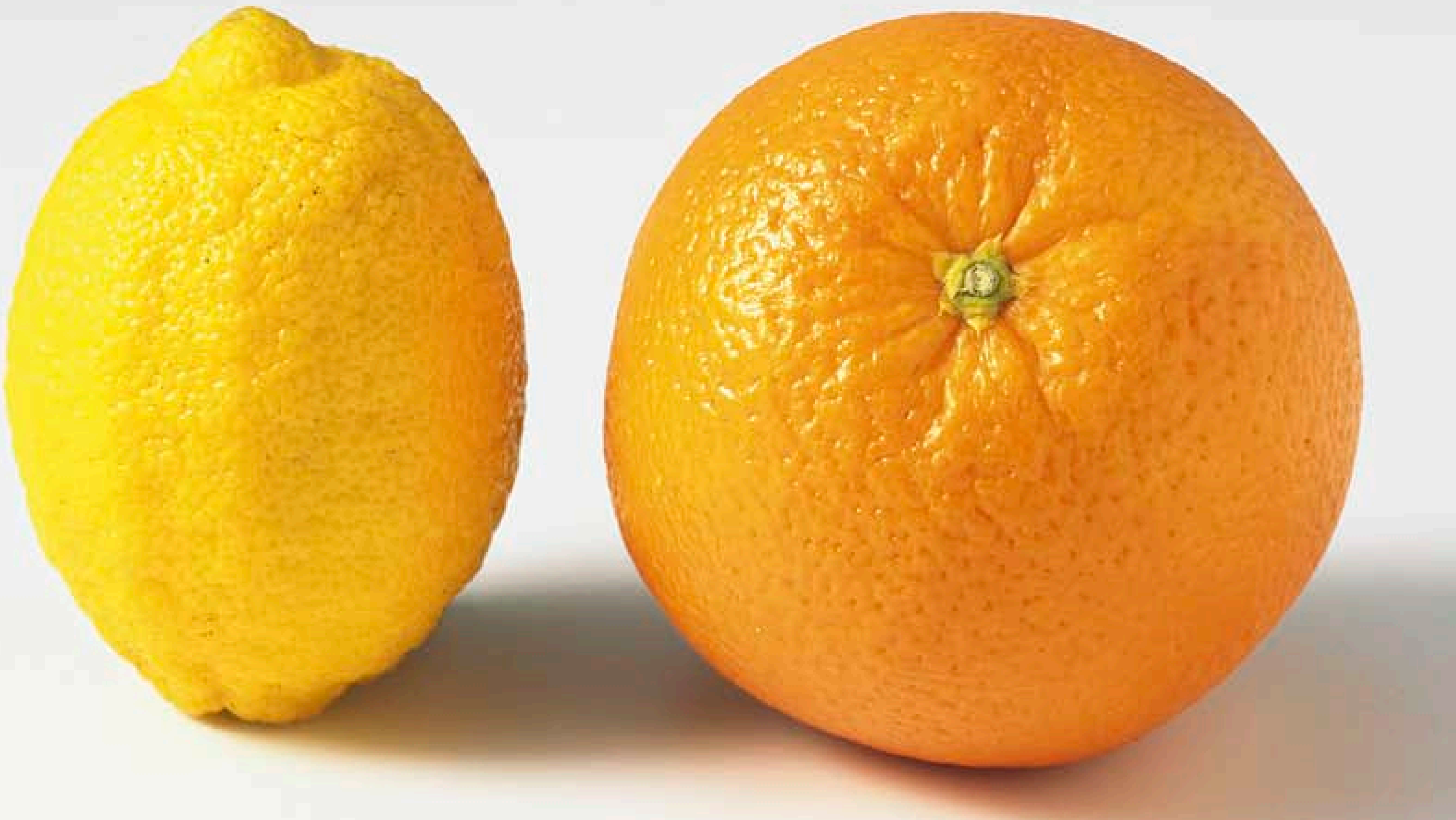
Industrial Ethernet

Comparison makes confident



Ethernet-based networks very quickly became a worldwide phenomenon due primarily to the explosive growth of the Internet. The universality of Ethernet together with the transport protocols it uses makes it the ideal medium for linking different applications. Ethernet is used across a wide spectrum of these applications: from email and Web browsing to transferring speech and video data.

High Expectations in Automation

Due to its high expansion in the area of information technology, Ethernet also has enormous potential for increasing productivity and reducing costs in industrial automation applications:

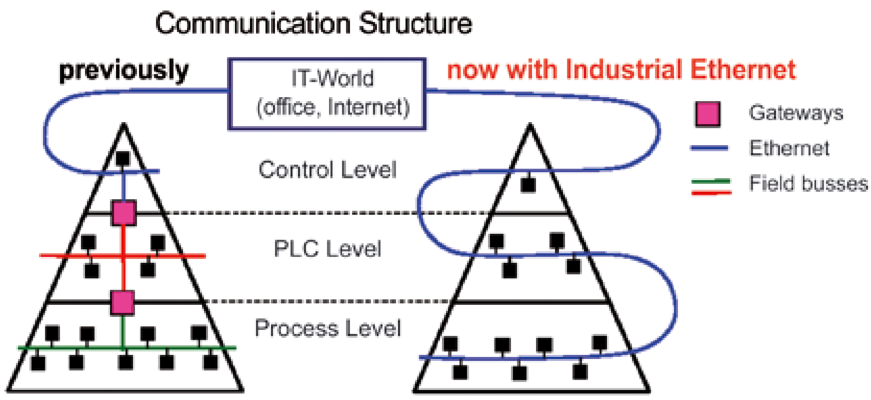
- Familiar technology with low initial expenditures
- Transparent and application-neutral protocols
- Worldwide networking for maintenance and monitoring
- Low dependency and large selection of suitable components
- 10-100 times faster data throughput when compared to other fieldbus technologies
- Distances of up to 100 meters using cost-effective copper cables

All in all, Ethernet technology promises higher performance, more throughput, and higher quality for production processes. That being the case, why isn't Ethernet being used in all of today's industrial applications?

Potential Entry Hurdles

For many years, Ethernet has been used to network control systems, management systems, and manufacturing cells, but not the devices inside the actual machines and equipment. In those areas, fieldbus technology continues to be used. In this case, the system divide needs to be bridged, requiring time-consuming adaptation of the protocols to the interfaces. Up until now, standardizing Ethernet and the Internet protocol from the control level down to the sensors and actuators has failed due to the reputed complexity, the limited availability of devices, and the actual real-time demands.

Lately, several different industrial Ethernet variants have been introduced and discussed in various trade magazines and other literature. This proliferation stems mainly from the different technical approaches to making Ethernet capable of handling real-time applications. Another reason for this variety is the attempt of many manufacturers to tie their users into their own proprietary networks for the long term. Frequently forgotten in these discussions is the fact that it's not just technical properties such as performance and transfer rates that count, it's also the soft facts like easy implementation, openness, conformity, interoperability, long-term availability, and overall distribution. This article will take a look at the four most well-known systems with these points in mind.



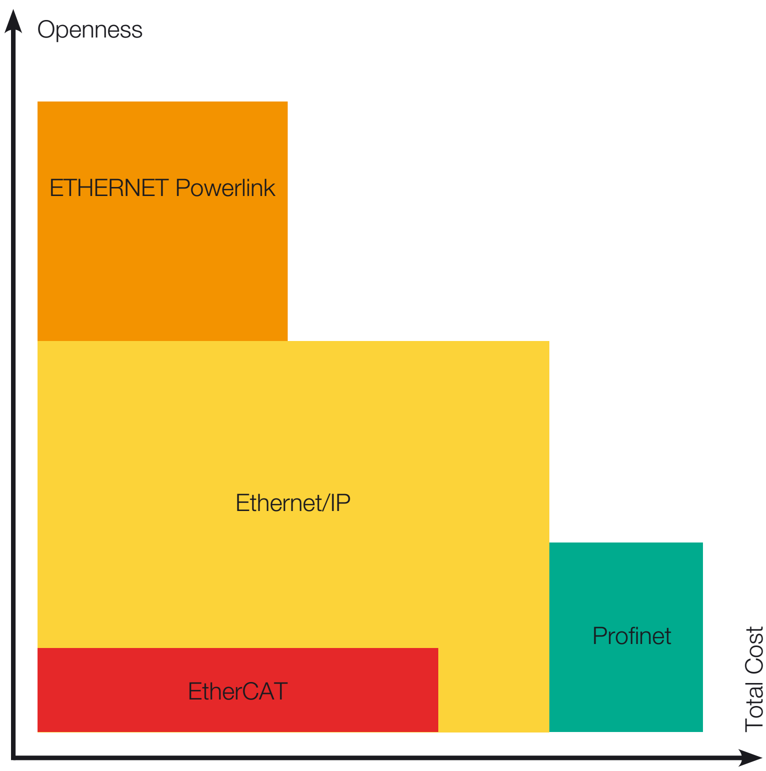
Industrial Ethernet promises a standardized networking environment from the control level down to the process itself.

PROFInet – Massively Complex

PROFInet is being managed and developed by the Profibus user organization under the auspices of Siemens. As a direct evolution from PROFIbus, uniform Ethernet technology is supposed to be able to handle all company areas down to the sensor and actuator level. Three different PROFInet specifications have been designed to meet different demands:

- PROFInet (previously V1) for applications with no real-time demands
- PROFInet RT (previously V2 or SRT) for moderate real-time demands
- PROFInet IRT (previously V3) for high real-time demands in drive applications

The first two variants can be implemented using conventional Ethernet devices and components. The IRT version demands new components that allow data to be transferred in real-time with microsecond precision.



PROFInet IRT transfers data cyclically and reserves isochronous and asynchronous communication channels. Communication paths for time-critical data are freed up isochronously at exact predefined times within the network. Information is then exchanged ad-hoc according to address, as is the case with switched Ethernet.

Commercially available Ethernet switch components are not familiar with the time-controlled communication for the isochronous channel and must be replaced by special PROFInet switch ASICs from Siemens. These components (the ERTEC 200 and ERTEC 400) were introduced earlier this year and are only available on test structures.

In order to be suitable for wide application, this technology must first get out of the teething phase. The complex switching between time- and address-controlled communication doesn't correspond to any standardized procedures and requires support from local software tools and special test and analysis tools. For future and faster (gigabit) Ethernet variants, new switch ASICs will need to be developed. In addition to the costs of the special components in all of the end devices and switches, costs for software and licenses must be taken into consideration as well. Providers of price-sensitive sensors and actuators will not be able to justify these costs.

In summary, PROFInet is pursuing a very universal approach that will lead to a high degree of complexity as well as a correspondingly higher price tag.

Ethernet/IP – Network Gurus Wanted

Rockwell Automation and the ODVA (Open DeviceNet Vendor Association) are the movers behind Ethernet/IP. Instead of referring to the more commonly known "Internet Protocol", the "IP" in this case stands for "Industrial Protocol", something that may cause overall confusion. The core of Ethernet/IP is the CIP (Common Industrial Protocol), which already forms the foundation for DeviceNet and ControlNet fieldbus technology. It is already being used today in time-uncritical applications. In order to penetrate into the application area of highly dynamic drive systems, the protocol variant CIPsync has been developed.

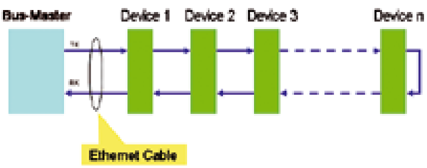
CIPsync makes sure that all of the stations in a network run synchronously and that real-time data is exchanged between them as needed. This synchronization is handled by distributed clocks in each device as well as by the IEEE 1588 synchronization protocol. Extremely precise timing, such as that needed for drive applications, requires special hardware clocks. The device clock stamps each time-critical message with the time. This makes it possible to clearly specify when inputs were read and at which times commands should be executed.

This IEEE 1588-based procedure, however, does not guarantee that data is transmitted at the right time. Time-critical messages are assigned a higher priority and handled first on the network. All other messages are then ranked lower accordingly.

Although Ethernet/IP uses familiar IEEE standards, high precision in this case requires all devices and components to be equipped with hardware clocks that are closely integrated with the Ethernet chips. These components are not yet available on the market. The necessary prioritization of messages demands detailed knowledge of Ethernet mechanisms and the volume of traffic on the network. Automation engineers will not be able to implement this technology without first being trained in the field of networks. Ethernet/IP is a switched network. Because of this, network analysis is only possible on a limited basis. The important line-formed network structures of devices so important in automation cannot be implemented. Finally, the overall performance of Ethernet/IP is strongly dependent on the total volume of network traffic.

EtherCAT – New Fieldbus or Industrial Ethernet?

The EtherCAT network, a further development of Beckhoff's Lightbus technology, is purported by the company to be the fastest industrial Ethernet system available. Being able to process 1,000 I/Os in 30 µs or 100 axes in 100 µs is a bold claim that needs to be closely analyzed.



With EtherCAT, all devices are networked in a ring formation.

All devices are networked with the bus master in a ring formation. During each cycle, relevant output data is extracted by the devices from the Ethernet data packets sent by the bus master. Input data is also stuffed into packets „on the fly"; these packets arrive again at the bus master upon reaching the end of the ring. This system was designed for centralized controller architectures with simple field devices. EtherCAT is not suitable for distributed intelligence. Individual devices can only communicate with one another by detouring over the bus master. The implied ring structure means that star-formed networks can only be implemented with limitations.

This technology can only be used with custom-made ASICs from Beckhoff. Despite several announcements, they are still not available. The first device prototypes that were used were expensive FPGAs. This is not an economical solution for manufacturers of price-sensitive sensors and actuators.

Although EtherCAT uses Ethernet packets, it doesn't have much else in common with the Ethernet standard beyond that. The individual devices cannot be used on conventional networks since MAC addressing isn't used. Even IP-based protocols have to go through the effort of being repackaged and virtually routed when sent. Transferring asynchronous data for parameters and diagnostic purposes incidentally wasn't covered at all in the performance data.

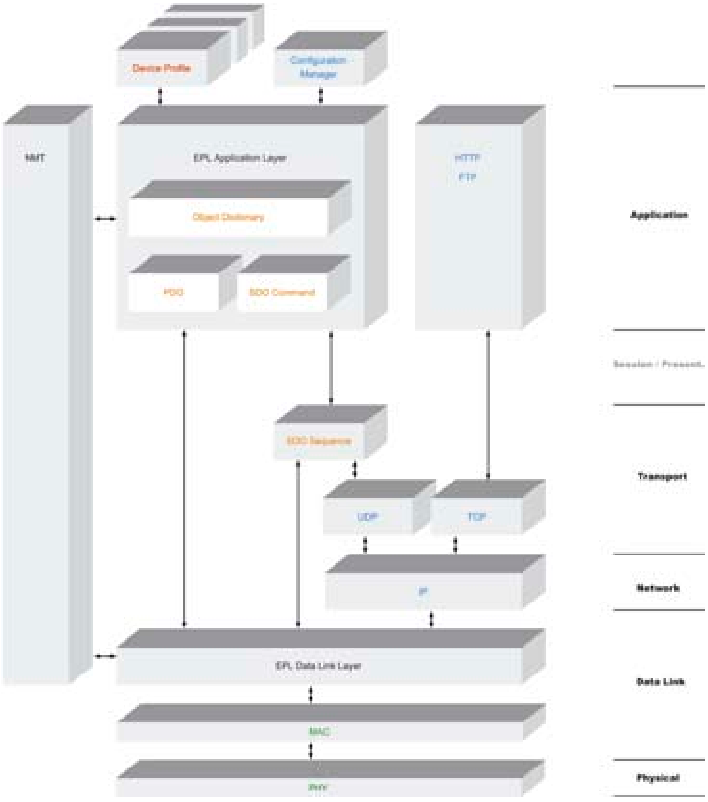
In addition to 100Base-T Ethernet, an E-bus has also been designed to reduce components and save approximately 1 µs at the expense of stability, electrical isolation, and compatibility. If the 100 axes described at the beginning of this section would be implemented with a standard physical structure, then 100 µs would be estimated just for the delay times of the devices alone. Because of this, the minimum possible cycle must be correspondingly higher.
To add to the confusion, this method is also integrated with the Beckhoff ADS, CANopen, and SERCOS communication profiles. To guarantee that devices from different manufactuers can work with one another, whether or not all devices support the same profile or the same physics (E-bus or 100Base-T) must be cleared up beforehand. For 100% interoperability, device manufacturers would have to invest time and effort for all possible variations.
In conclusion, EtherCAT is a new fieldbus that has some Ethernet properties. The technology itself has been partially made public and protected by Beckhoff through the use of several patents. Whether this network gains wide acceptance will depend primarily on its availability, price, and risk analysis when Beckhoff ASICs are taken into consideration.

ETHERNET Powerlink – With Openness Comes Success

ETHERNET Powerlink was introduced by B&R in 2001. Its goal was to provide standard Ethernet with real-time properties and allow universal solutions all the way down to demanding motion applications. Since that time, the EPSG (ETHERNET Powerlink Standardization Group) has promoted ETHERNET Powerlink and taken responsibility for its openness, continuous improvement, and independence.

ETHERNET Powerlink is a strictly cyclical protocol that organizes the access to a network as well as the synchronization of the devices. Its cyclic precision is under 1 µs. The communication cycle is divided into an isochronous phase for time-critical data as well as an asynchronous phase for transferring ad-hoc data. All of the devices on the network can always directly read all of the data from the other devices. Detouring over a central bus master (as with EtherCAT) is not necessary. This protocol is equally suitable for local as well as remote control designs.

Its electrical properties and all of its data packets correspond to the Ethernet standard. For example, ETHERNET Powerlink transmits data in the asynchronous phase using standard IP telegrams. Implementations are cost-effective because they



The ETHERNET Powerlink protocol stack is based on established international standards.

can be carried out with any Ethernet chip currently on the market. Controllers can achieve extremely short cycle times of 100 µs.

The interoperability of devices from different manufacturers is guaranteed by the 100Base-T physical structure as well as its integration with the widely used CANopen communication and device profiles. For network analysis, commercially available tools and shareware programs from the IT world can be used without modifications. Unlike the other three methods, all data packets can be viewed at any measuring point without limitations.

As of June, 2005, ETHERNET Powerlink is supported by more than 300 companies worldwide with more than 70,000 nodes in series production machines and systems in several different industries. Many leading companies are already offering fully developed products and services. This protocol is also distinguished by its easy application without needing special networking know-how. Going beyond its excellent real-time properties, ETHERNET Powerlink has recently been expanded to include the EPLsafety protocol layer for safety-critical applications according to IEC 61508 up to SIL 3 (up to SIL 4 with limitations).

The idea behind ETHERNET Powerlink is to find the right balance between common automation demands and those demands that are specific to each application area. This is leading to a widely accepted solution that can be adapted in just a short amount of time. ETHERNET Powerlink ensures quick market entry for manufacturers and users and is still the only real-time industrial Ethernet system currently in series production on the market.

Summary

Although the discussion that surrounds industrial Ethernet solutions frequently centers on such academic topics as the right method and the fastest technology, the long-term market will only accept solutions that are open, proven, easy to use, future-oriented and that conform to standards and support interoperability. Users have become extremely cautious about proprietary systems since they can lead to unpredictable dependence that cannot be easily lifted. The success of ETHERNET Powerlink lies in its open access to technology and its transparent development using concepts and ideas from all different application areas. Countless applications in machine and system manufacturing, measurement technology, the transport industry, and energy production affirm this path.

A Guest Article by:

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EPSG, Winterthur

The EPSG (ETHERNET Powerlink Standardization Group) was founded in Winterthur/Switzerland in June 2003 as an independent association. Originating from a group of leading automation companies, its focus is leveraging the advantages of Ethernet for high performance Real-Time networking systems based on the ETHERNET Powerlink Real-Time protocol, introduced by B&R at the end of 2001.

The EPSG has clear organisational structures, thereby ensuring transparent decision processes. Various working groups focus on different areas, such as safety, technology, marketing, certification and end users. The EPSG furthermore cooperates with leading standardization bodies and associations, like the CAN in Automation Group, the IAONA, the IEC and the ISO.

The idea of the EPSG is to maintain the balance between a common understanding of automation technology and the demands of different directions. This results in widely acceptable solutions, which can be implemented on short terms.

www.ethernet-powerlink.org

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