



Networks built on a  
Common Industrial Protocol

Multi-axis synchronized motion...



***CIP Motion™***

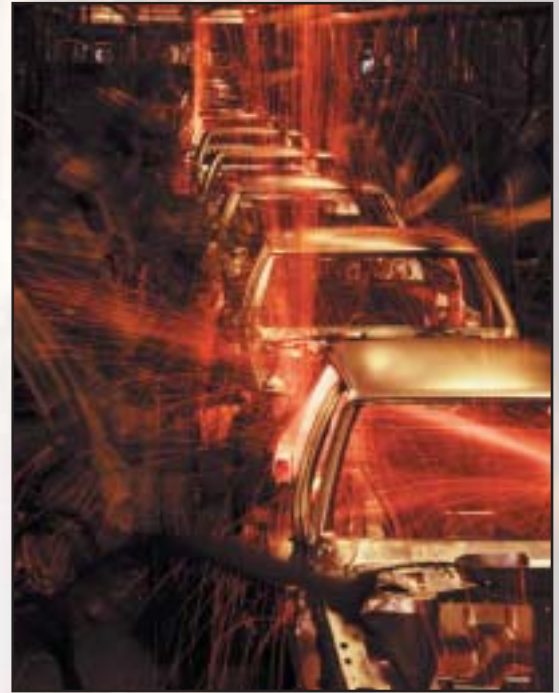
...over EtherNet/IP



## Performance demands on motion networks

As much as OEMs and end-users try to standardize on as few different networks as possible, the reality of high performance, deterministic, real-time motion control is that a number of different networks are often needed. Standard fieldbus options don't have the bandwidth to handle demanding motion control, while the dedicated motion interfaces don't offer the additional support for variable speed drives, sensors and other field I/O devices.

But when more than one network needs to be supported, the inevitable results are increased configuration complexity, reduced system performance and higher system cost.



## Industrial Ethernet

With its huge commercial base and wide bandwidth, industrial Ethernet offers the potential to combine the required performance of a motion control network with the wider demands of a field network.

Unfortunately, most industrial Ethernet networks do not offer support for motion control. Or, if they do, then they do so by adding proprietary technology to standard Ethernet, negating the key benefit of industrial Ethernet by turning it into something that is essentially the property of a small group of vendors.

EtherNet/IP is different. **Only EtherNet/IP with CIP Motion technology combines the requirements of deterministic, real-time, closed loop motion control with 'standard' Ethernet, offering full compliance with Ethernet standards, including IEEE 802.3 and TCP/IP.**



## EtherNet/IP and CIP Motion

EtherNet/IP with CIP Motion technology provides an open, high bandwidth, high performance solution for multi-axis, distributed motion control.

CIP Motion is an extension to CIP (Common Industrial Protocol), delivering the capability necessary for high performance, multi-axis, synchronized motion.

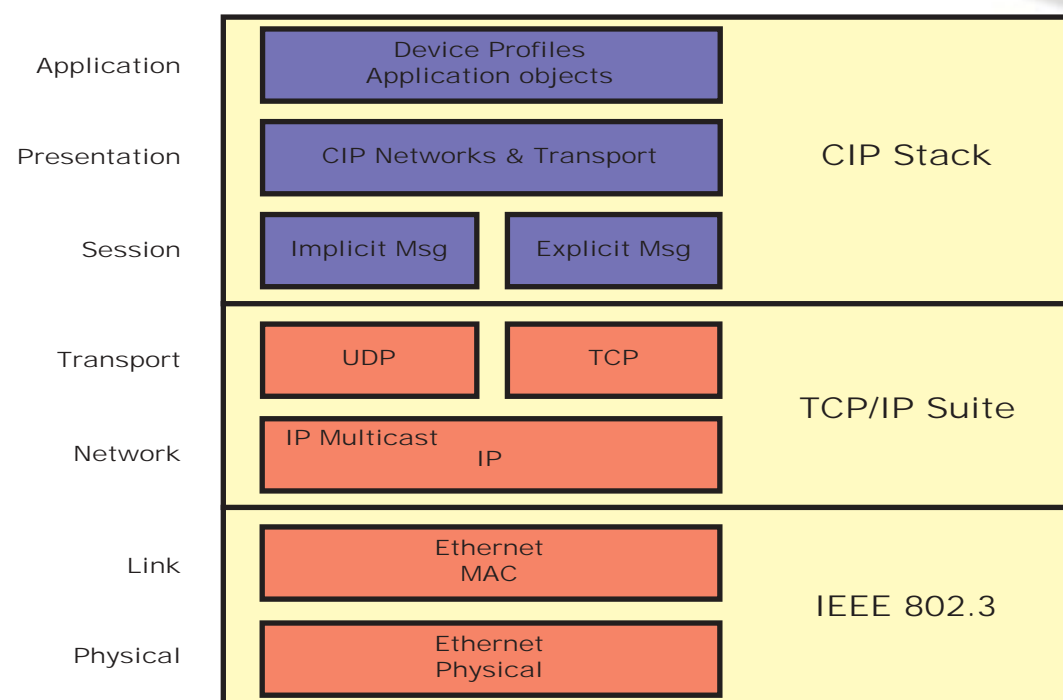
CIP Motion encompasses a set of application profiles designed to allow position, speed and torque loops to be set within a drive. This combines with ODVA's CIP Sync technology – IEEE-1588 compliant Precision Clock Synchronization mapped into the CIP object model.

**EtherNet/IP with CIP Motion delivers on the promise of motion control over standard, unmodified Ethernet.**

EtherNet/IP with CIP Motion allows multiple axes to be coordinated for precision, synchronized motion control.

Further, EtherNet/IP with CIP Motion is a scalable and comprehensive solution that provides a common application interface and services for general purpose and motion control drives using the same profile.

EtherNet/IP with CIP Motion is compatible with standard Ethernet topologies such as star and trunk/line dropline.





## The solution to determinism

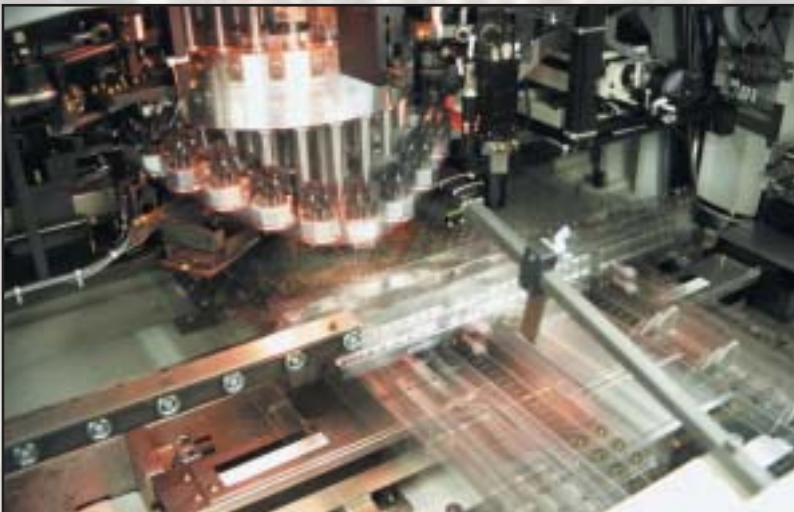
Typically, multi-axis motion control uses event-based synchronization, which requires scheduled, absolute hard delivery of time-critical cyclic data across the network. Jitter of less than  $1\mu\text{s}$  for cyclic data is necessary for precise speed and/or position control, but Ethernet's CSMA/CD data layer is not capable of delivering data with less than  $1\mu\text{s}$  of jitter.

This determinism problem might seem to rule out standard unmodified Ethernet for motion control, but ODVA has overcome this limitation with EtherNet/IP without resorting to changing any of the four lower layers of Ethernet, using standard, unmodified Ethernet and TCP/UDP/IP.

**EtherNet/IP with CIP Motion solves the problem by changing the strategy for determinism. It removes the requirement for strict determinism from the network infrastructure and entrusts the end devices with the timing information necessary to handle the real-time control needs of the application.**

EtherNet/IP with CIP Motion can thus deliver the high performance, deterministic control required for closed loop drive operation, using standard, unmodified Ethernet. Clock synchronization of better than 200ns can be readily achieved, meeting the needs of the most demanding motion control applications. Because the clocks in the end devices are tightly synchronized, a small amount of jitter in receipt time of the message is unimportant, because information in the message is time-stamped.

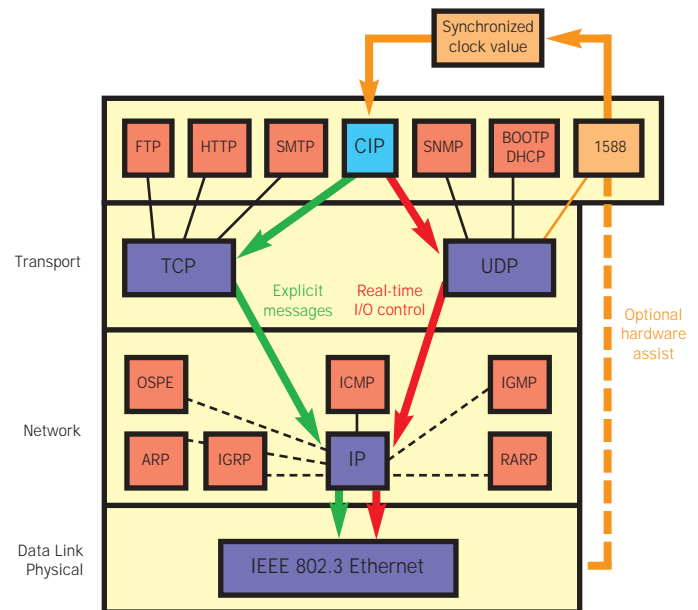
EtherNet/IP with CIP Motion allows 100 axes to be coordinated with a 1ms network update to all axes.



## Time Synchronized Distributed Control

EtherNet/IP's implementation for motion applications uses an approach called 'Time Synchronized Distributed Control', where time-stamped data packets relax the strict requirement for less than 1µs jitter for cyclic data delivery.

At the heart of this approach is CIP Sync, which defines time synchronization services for CIP. These time services provide a distributed time reference for the packet time stamping used in the Time Synchronized Distributed Control scheme. With time synchronization, it is possible to synchronize services across distributed nodes.



### CIP Sync is fully compliant with the IEEE-1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

With this innovative approach the CSMA/CD data link layer does not have to be replaced with a proprietary driver or ASIC, allowing full IEEE 802.3 compliance, while providing a robust solution with the performance necessary for closed loop operation of high performance digital drives.

There are many advantages to maintaining full IEEE 802.3 compliance:

- **Use of standard Ethernet hardware components** including Ethernet chips and infrastructure components such as switches and routers. This results in reduced systems cost because standard, high volume, commercially available components and infrastructure can be used. Furthermore, the Ethernet network on the factory floor is no longer 'special' or 'proprietary' and can be supported using readily available standard Ethernet tools
- **The network does not have to be scheduled** – scheduling the network results in added configuration complexity
- **The packet size and content can be dynamically changed** – this facilitates features like dynamic inclusion or deletion of status or command data, and dynamic drive operating mode changes
- **Any Ethernet IEEE 802.3 compliant device can reside on the network** without use of special switches or gateways
- **Compatible with standard Ethernet topologies** such as star and trunk/line dropline
- **Upgrading to 1 Gigabit/sec and 10 Gigabit/sec** for even greater performance is very easy for both users and device suppliers.



## CIP Motion profile

The CIP application profile used on EtherNet/IP provides a comprehensive set of services and device profiles that provide a wide range of functionality and device support.

CIP Motion extends the CIP capability by defining extensions focused on drive control:

- Torque, velocity, or position control of servo and variable speed drives
- Drive configuration, status, and diagnostic attributes and services
- Unicast control-to-drive communications
- Multicast peer-to-peer communications
- Centralized and distributed motion support

The CIP Motion profile delivers common configuration services, common status and diagnostic services, and common application instruction support for variable speed drives and servo drives, making them interchangeable at the application level.

The controller-to-controller communication is focused on functions such as distributed position and velocity gearing and camming. This allows drives control by multiple distributed controllers to be position and velocity synchronized.

**The CIP Motion profile takes advantage of the latest advances in motion control technology to provide a comprehensive, state-of-the-art profile.** Use of floating point data eliminates the complexity typically associated with integer math and scaling.





## Building on unmodified Ethernet

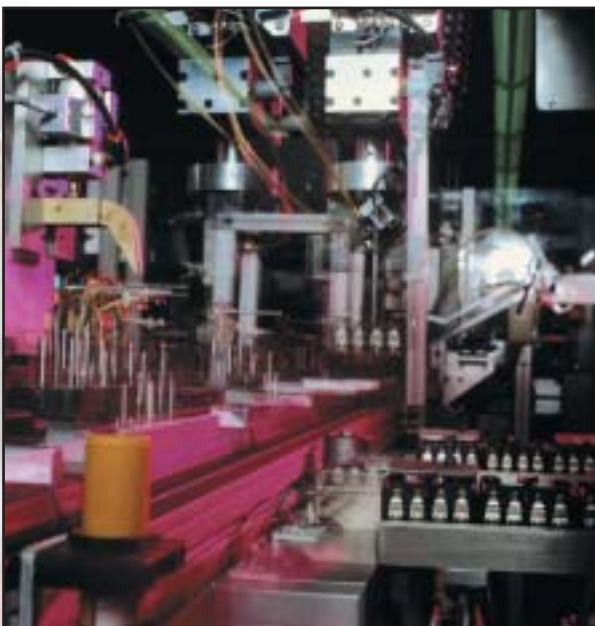
The promise of Ethernet on the plant floor is that many different networks will converge into one network, which can be installed once, using universal training sessions and one set of tools.

Distributed motion control over Ethernet represents one of the last pieces of puzzle in realizing this goal. And with EtherNet/IP and CIP Motion, ODVA has delivered a real-time, closed loop distributed motion solution which is based on standard, unmodified Ethernet.

Retaining IEEE 802.3 and TCP/IP compliance allows use of standard Ethernet components and infrastructure, provides support for any IEEE 802.3 compliant nodes without the use of special switches or gateways, and allows support of future Ethernet enhancements.

EtherNet/IP with CIP Motion allows 100 axes to be coordinated for precision, synchronized motion control. CIP Motion provides comprehensive support for variable speed drives and servo drives, unicast controller-to-drive communications, multicast controller-to-drive, and controller-to-controller communications.

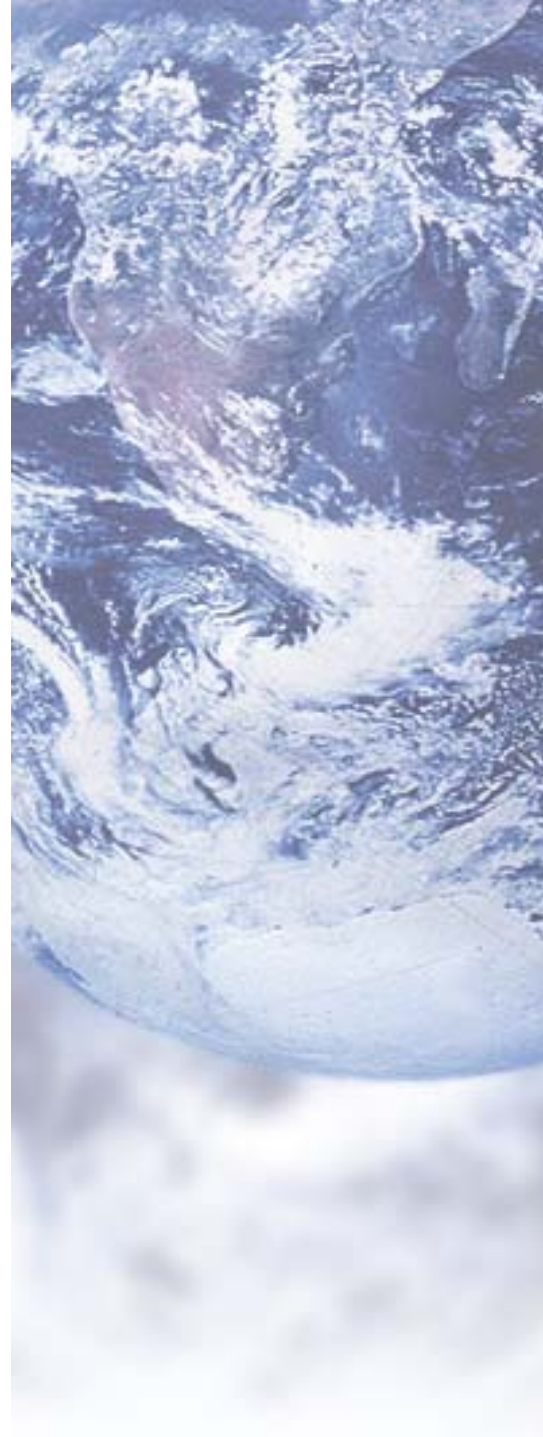
With the CIP Motion extensions, EtherNet/IP will allow integration of field devices and motion drives on the same network, eliminating the need for a separate motion optimized network. This provides lower system cost, improved system performance, and greatly reduced system complexity.



Taking advantage of unmodified Ethernet also provides a clear migration path beyond 100MBps to 1GBps Ethernet and even 10GBps Ethernet. This will soon allow even more demanding distributed motion applications to be satisfied, or enable even more valuable information to be transmitted across the network.

## **About ODVA**

ODVA is an international association comprised of members from the world's leading automation companies. Collectively, ODVA and its members support network technologies based on the Common Industrial Protocol (CIP™). These currently include DeviceNet™, EtherNet/IP™ along with major extensions to CIP – CIP Safety™, CIP Sync™ and CIP Motion™. ODVA manages the development of these open technologies, and assists manufacturers and users of CIP technologies through tools, training and promotional activities. In addition, ODVA offers conformance testing to help ensure that products built to its specifications operate in multi-vendor systems. ODVA also is active in other standards development organizations and industry consortia to drive the growth of open communication standards. For more information, visit the ODVA web site at: [www.odva.org](http://www.odva.org)



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