# How Ethernet Brought Determinism to a Wider Range of Industrial Systems

## Ethernet Has Increased the Reach of Determinism in Industrial Systems

At one time, determinism in industrial networks was predominantly the province of coordinated motion and CNC-style applications.[1] It was widely assumed that the central applications in fields like oil and natural gas, wind power, and even some types of manufacturing, would never really require the demonstrable efficiency boost that determinism could provide.

## Why Determinism Used to be Limited to Only a Few Applications

The reason for this assumption? For starters, the decades-long increase in Ethernet speeds as well as the gradual replacement of serial networks with Ethernet-based protocols (for example, Modbus® TCP, EtherNet/IP®, and PROFINET®) meant that automation and control systems were continually becoming faster and getting access to more bandwidth. The gains from these transitions were significant enough to make the benefits of determinism seem secondary in comparison.

There was also the practical matter—or rather, impediment—of ensuring determinism in a standard (IEEE 802.3 Ethernet) that did not initially contain it. Although Ethernet was always higher bandwidth than half-duplex and inherently deterministic serial connections like RS-232 and RS-485, its time frame for a response was unpredictable prior to the codification of full-duplex switched Ethernet in the 1990s and the development of commercial industrial Ethernet protocols.

A protocol like PROFINET is emblematic of how Ethernet solutions have tackled issues of determinism and ease of implementation in industrial networking. PROFINET actually defines three protocols designed for different response ranges, from 100 ms to less than 1 ms.[2] To achieve differentiation, it bypasses standard TCP/IP (suitable for the least demanding of its three tiers) when processing workloads that require real-time or isochronous real-time performance for swifter cycle times.

PROFINET is also an open protocol, albeit one that many vendors have modified for their own ends. Like alternatives such as EtherCAT, it promises relatively easy and cost-effective integration into existing systems, with most of the changes at the application layer. Plus, the overall implementation is helped by the large vendor ecosystem. Such advantages, as well as the general evolution of Ethernet, have made implementing determinism increasingly feasible not just in motion-centric architectures but also in something simpler, like a PLC system.

## How Ethernet Enabled More Widespread Use of Determinism

Perhaps it is ironic that Ethernet, a nondeterministic standard, has paved the way for determinism across a variety of industrial systems. Still, it is fast, usable over long distances, and capable of carrying many types of data on a single wire. Important nodes no longer have to be so closely positioned together to ensure on-time delivery, as was the case with some proprietary fieldbuses. Cabling has also been simplified, making determinism via Ethernet even more appealing since it lends itself to streamlined management and costs.

"This functionality used to exist only in standalone solutions, such as functional safety, condition monitoring, and data acquisition systems,"[1] Joey Stubbs of the EtherCAT Technology Group told *Automation World* in 2012. "For the user, this cuts costs and reduces programming effort while increasing the overall system's diagnostics capabilities. Now these subsystems can be simply implemented as software modules in the main controller and all variables, diagnostics, and states can be freely communicated, instead of having separate hardware add-ons for each subsystem."

Of course, adding determinism to a network can create complications about interoperability and communications, since another layer is being added to basic TCP/IP a la what PROFINET utilizes for its higher performance protocols. Manufacturers will have to ensure that they are casting their lot with an Ethernet solutions vendor that meets their particular business requirements. Determinism can produce significant gains in many systems and they can really add up over the entire lifespan of an application.

## References

1 Terry Costlow. "Network Determinism: Not Just for Motion Anymore." *Automation World*, February 2012.

2 "Understanding Ethernet Speed and Determinism." *Automation World*, November 2011.

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