PROFINET for Network Geeks

(and those who want to be)

Introduction

PROFINET is an open Industrial Ethernet standard. It is a communication protocol that exchanges data between automation controllers and devices. With over 25 million installed nodes (as of 2018), PROFINET is one of the most widely used Industrial Ethernet standards worldwide. But even though millions of users are familiar with PROFINET, not all users understand how it works. This white paper starts with a brief overview of Ethernet and the 7-layer ISO-OSI model. Then, it describes how PROFINET's 3 communication channels fit in the model: TCP/IP and UDP/IP, Real-Time (RT), and Isochronous Real-Time (IRT).

Ethernet

The transition from using 4-20 mA analog signals for I/O communication to digital fieldbuses provided the benefits of reduced wiring, access to network data, and robust diagnostics. The later transition from digital fieldbuses to Ethernet was also similarly a shift to a more modern technology. Ethernet incorporated and improved upon the benefits of fieldbuses.

Ethernet is ubiquitous and PROFINET uses standard Ethernet. Ethernet gives PROFINET the ability to provide faster updates, more bandwidth, larger messages, an unlimited address space, and even more diagnostic capabilities. Also, as commercial Ethernet evolves, PROFINET can take advantage of these physical layer improvements.

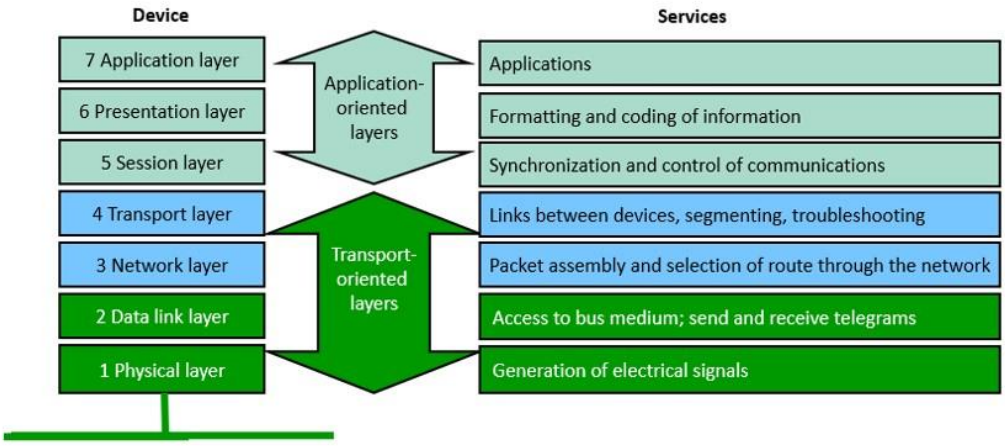

Figure 1 ISO-OSI Model

The ISO-OSI Model

Ethernet-based communications can be represented by a seven-layer model: the ISO/OSI Reference Model. The model generically describes the means and methods used to transmit data. Each layer has a specific name and function, as shown in Figure 1. The layers from the bottom to the top are: Physical, Data link, Network, Transport, Session, Presentation, and Application.

Since the most widely used implementation of the ISO/OSI Model is the Internet, a simplification can be performed by collapsing the 7 layers down to 4, as shown in Figure 2. PROFINET uses these four but not all of the time; it depends on the application.

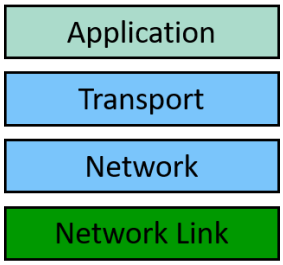

Figure 2 The Internet: 4-layer simplified model

Layers 1 and 2: Combined and defined by IEEE802.3, Ethernet

Layer 3: The IP (Internet Protocol) Layer

Layer 4: The TCP or UDP Layer (Transmission Control Protocol, User Datagram Protocol)

Layer 7: The application Layer

Some protocols use all four layers, while other protocols just use Ethernet plus the application layer: Address Resolution Protocol (ARP), for example. An arriving Ethernet frame is directed to the next layer based on a standard field defined in every Ethernet packet called the EtherType. There are hundreds of EtherTypes. To direct frames to the IP Layer, "0×0800" is used. ARP's EtherType is "0×0806", and is the method that directs its frame directly to Layer 7.

PROFINET Communication Channels

PROFINET can use TCP/IP (or UDP/IP) communications for certain non-time critical tasks, such as configuration, parameterization, and diagnostics. When sending data via TCP/IP, additional information is added to the packet as it 'moves' through the layers. This additional information, shown in Figure 3, can make Ethernet frames relatively large. When sending such Ethernet frames, the sender 'packs' the data and the receiver 'unpacks' it. Generally, this process is called encapsulation. Encapsulation can add significant jitter and latency. Therefore, the TCP/IP communication channel is unsuitable for time-critical tasks.

PROFINET RT handles time-critical data exchange. An arriving PROFINET RT Ethernet frame has the PROFINET EtherType: 0×8892. Upon arrival, the frame is directed to the PROFINET application directly from Layer 2 to Layer 7. The frame skips the TCP/IP layers and avoids the variable time it takes to be processed. Thus, communication speed and determinism improve significantly. PROFINET RT meets more than 90% of industrial automation timing requirements, and almost all PROFINET frames are sent via this method.

For the most demanding applications, PROFINET can use additional techniques for even faster performance with the PROFINET IRT channel. PROFINET IRT is a step beyond PROFINET RT. Unavoidably, under high network traffic, some time-critical messages can gain jitter. IRT eliminates those delays by enhancing the rules employed to switch Ethernet traffic, and by creating special rules for this PROFINET traffic (not covered in this white paper).

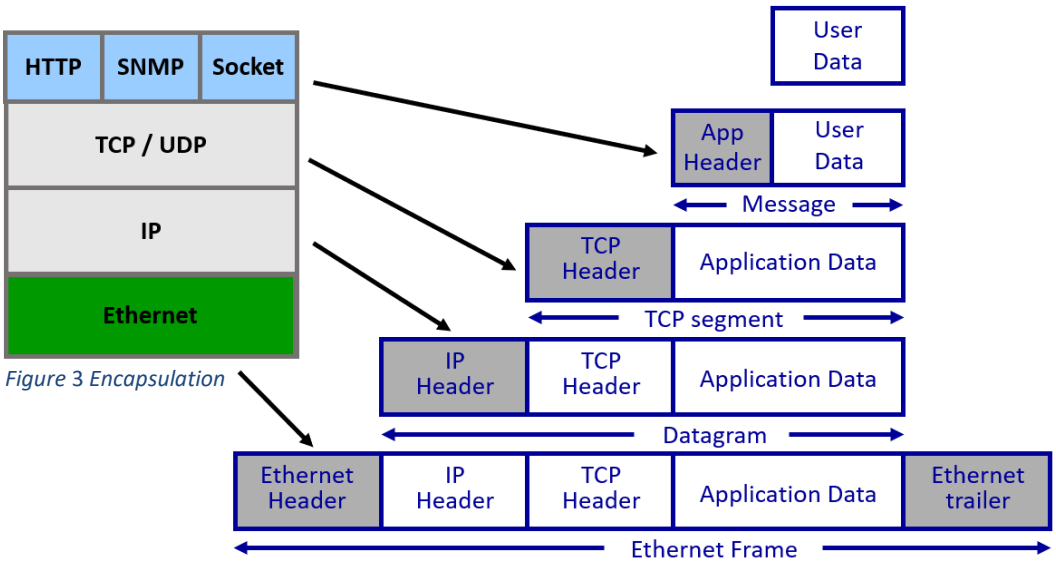

Figure 3 Encapsulation

Summary

With more than 25 million installed nodes worldwide, PROFINET has proven exemplary performance and robustness in its networks. PROFINET moves data efficiently with different communication channels. It uses standard UDP/IP and TCP/IP communication for non-time-critical tasks. For time-critical messages, it employs PROFINET RT by default. These messages have the predetermined EtherType (0x8892) which directs frames right to the PROFINET application. This allows PROFINET to improve both speed and determinism. Finally, for the most demanding applications, PROFINET employs the IRT channel.

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