# AN4826

# LAN9662/LAN9668 PROFINET Operation

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## INTRODUCTION

This application note describes the PROFINET operation and how the following LAN966x family of TSN-capable Ethernet devices can be used within a PROFINET industrial network:

- LAN9662 4-port TSN endpoint
- LAN9668 8-port TSN switch

PROFINET is a data communication protocol that supports real-time transfer of data from one location to another via Ethernet. PROFINET uses a number of mechanisms for communication, such as:

- Shaping
  - Credit-based shaping IEEE802.1av
  - Time-aware shaping IEEE802.1bv, also referred to as TAS—this mechanism reserves time slots in the network for priority traffic
- Queue system behavior shaping—reduced latency on express traffic
  - Cut-through: There is no standard for this, which means that transmission of a frame is started before the entire frame is received. This reduces latency.
  - Preemption, IEEE802.Qbu + 802.3br: The transmission of a low-priority frame can be interrupted at the expense of a high-priority frame. The transmission of the low-priority frame can continue where it left off when the high-priority frames have been transmitted.
  - Per-stream filtering and policing (PSFP), IEEE802.1Qci
- Time synchronization—common understanding of time
  - Participating devices need a common understanding of time
  - IEEE802.1AS (gPTP), a subset of 1588
  - Supporting multiple time domains
- Protection and network redundancy
  - Frame Replication and Elimination for Reliability (FRER) IEEE802.1CB
  - IEC-62439-2 2016 Media Redundancy Protocol (MRP)
  - Linear and Ring protection G.8031/G.8032
  - Device Level Ring (DLR) as per Open DeviceNet Vendors Association (ODVA)
  - IEC-61158-6-10 Profinet Fieldbus Application Layer (MRPD)

PROFINET and PROFIBUS are defined in IEC 61784. At the time of writing, the latest revision of this standard is *IEC CD 61784© IEC 2022*. In this standard, the Communication Profile Family 3, or CPF-3 for short, is defined. This family is a set of Communication Profiles named CP 3/1 through CP 3/7. The first three profiles are for PROFIBUS and the rest (that is, CP 3/4 through CP 3/7) is for PROFINET.

This application note covers the PROFINET profiles. These four PROFINET profiles are commonly referred to as Conformance Class A to D (that is, CC-A, CC-B, CC-C and CC-D).

- CC-A (CP 3/4) is also known as PROFINET-RT
  - Allows cycle time down to 1 ms, most do not go lower than 10 ms
  - Requires LLDP integration and a number of optional features like SNMP, MRP, and more
  - Supports LAN9662 and P-NET stack
- CC-B (CP 3/5) is CC-A + SNMP
  - Supports LAN9662. Hardware and API are the same as CC-A.

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- CC-C (CP 3/6) is also known as PROFINET-IRT
  - Low cycle time, with motor control design consideration
  - Originated from pre-TSN days, not compatible with standard Ethernet
  - Not supported by LAN9662
- CC-D (CP 3/7) is also known as PROFINET over TSN
  - Cycle time down to 31.25 µs
  - Targets the same market as CC-C, but with technology based on IEEE standards
  - Uses Frame Preemption, gPTP and TAS
  - LAN9662 is designed to support CC-D.

In PROFINET, the terminologies, IO controller (IOC) and IO device (IOD), are used. An IOC is typically a Programmable Logic Controller (PLC) and an IOD, which is also called a field device, can read and/or write values. An IOC and an IOD run a state machine to exchange values. The one end of a value runs a Provider Protocol Machine (PPM), and the other end runs a Consumer Protocol Machine (CPM). If an IOD reads a value that will be sent to an IOC, then the IOD must run a PPM for this value and the IOC must run a CPM. If the direction of the value is in the opposite direction, then the protocol machines are swapped:

**FIGURE 1: COMMUNICATION EXAMPLE BETWEEN IOC AND IOD**

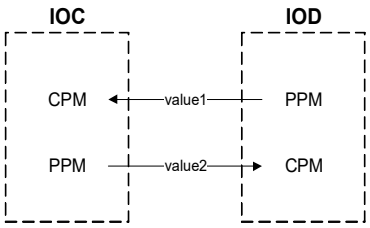


Figure 1 illustrates that `value1` is sent from an IOD to an IOC, and `value2` is sent in the opposite direction.

The LAN9662 has a hardware offload for PPM and CPM machines, and it can be used to build an IOC and an IOD. However, it must be noted that IOCs and IODs have different feature requirements. An IOD can be built using P-NET and an IOC cannot.

**Note:** See https://rt-labs.com/profinet/microchip-lan9662-integration-with-p-net-profinet-stack/ and https://rt-labs.com/docs/p-net/reference-library/lan9662/ for more information on the use with P-NET.

The LAN9668 cannot offload PPM or CPM. The LAN9668 is intended for building a TSN switch.

## Sections

This document includes the following topics:


- LAN9662 and LAN9668 on page 3
- Hardware Overview on page 3
- Software Overview on page 3
- Standalone Tools on page 4


## References

Consult the following references for details on the specific parts referred to in this document:

- *LAN9662 Data Sheet*
- *LAN9668 Data Sheet*
- *EVB-LAN9662 Evaluation Board User's Guide*
- *EVB-LAN9668 Evaluation Board User's Guide*
- *LAN9668 U-Boot Upgrade for EVB-LAN9668* (https://microchipsupport.force.com/s/article/Upgrading-LAN9668-U-Boot-to-Release-2022-06-on-an-EVB-LAN9668-Evaluation-Board)


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## LAN9662 AND LAN9668

For each of the LAN9662 and LAN9668 devices, there is a corresponding evaluation board:

- LAN9662: EVB-LAN9662 CPU board (also called UNG8291 B)
- LAN9668: EVB-LAN9668 board (also called UNG8290 B)

| **Note:** | There is also an EVB-LAN9662 carrier board (also called UNG8309 B), which is an extension board to the EVB-LAN9662 with additional port connectors and an FPGA. |
|---|---|

For more information about these evaluation boards, refer to the documents in the References section.

### Hardware Overview

The EVB-LAN9662 evaluation board has an Edge connector that is SODIMM type. On this connector, GPIO1,..., GPIO77, QSPI, S0, S1, S2 and PCIe® are provided. This Edge connector is used when plugging the EVB-LAN9662 into the EVB-LAN9662 carrier board. On this carrier board, there is an FPGA (IGLOO2 FPGA M2GL050), where the signals GPIO1,..., GPIO77 and QSPI are connected.

The LAN9662 is not considered a switch. In order to build a TSN switch, the LAN9668 can be used. The LAN9662 has hardware to process PROFINET frames. This hardware is referred to as the Real-Time Engine (RTE). The RTE runs the PPM and CPM state machines. The PROFINET frames can be processed by the RTE without involving the CPU, except for initial configuration. Depending on the requirements, PROFINET frames can be handled entirely in hardware. In this case, PROFINET values are exchanged over the QSPI interface. Another use case is that the RTE exchanges values via the RAM area in the chip instead. From there the CPU can read and write values.

Although the CPU can handle PROFINET frames on its own, the use of the LAN9662 speeds up the PROFINET protocol data transfers.

### Software Overview

In this section, references to EVB-LAN966*x* and LAN966*x* apply to both LAN9662 and LAN9668.

The hardware in the LAN9662 is supported via Switchdev plus some proprietary tools. This software/tool package is referred to as standalone software. This standalone software can also run on the LAN9668.

The EVB-LAN966*x* is equipped with a NOR and an e-MMC™ Flash device. The LAN966*x* can boot from either device, depending on the DIP-switch setting on the EVB-LAN966*x*. This DIP switch has four contacts marked VCORE0, VCORE1, VCORE2, and VCORE3. See the *LAN9662/LAN9668 Data Sheet* for DIP switch setting descriptions.

When an EVB-LAN966*x* is obtained, it is recommended that the software be upgraded to the latest release. See the *LAN9668 U-Boot Upgrade for EVB-LAN9668* for upgrade instructions.

The bootloader code can be found at https://github.com/microchip-ung/arm-trusted-firmware. On the GitHub page, the available releases are shown. As of this writing, the latest release is 1.0.5. Click **Latest** to show the number of files, and use the `lan966x_b0-release-bl2normal-auth.fip` file.

Apart from the bootloader, the Linux® application is required with Switchdev support for the LAN966*x* hardware. For the EVB-LAN966*x* board, the Linux application can be found by downloading the board support package (BSP); see **Appendix A: "Installing the BSP"**. The standard standalone binary can be found by running the command:

```
$ find /opt/mscc/mscc-brsdk-arm-2023.06/ -name "*.ext4.gz"
```

This finds the `brsdk_standalone_arm.ext4.gz` file that can be installed by using the procedure in **Appendix A: "Installing the BSP"**.

The LAN9668 is also supported by Microchip's common switch applications like WebStaX, SMBStaX, and IStaX. Of these applications, IStaX is the most relevant because it supports TSN features that are significant to PROFINET. IStaX is the default software in the EVB-LAN9668 board. If the board needs to be upgraded and the switch application source code was not purchased, contact the Microchip customer service to request it. The switch application filename is `istax_ lan966x.ext4.gz`. Note, however, that although the name indicates *lan966x*, the file does not work with LAN9662 but only with LAN9668.

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## Standalone Tools

Table 1 lists a set of tools in this version:

**TABLE 1: STANDALONE TOOLS**

| Name | Origin | Example |
|---|---|---|
| Iproute2 suite | Linux community | ip, bridge, tc |
| ethtool | Linux community | ethtool |
| ptp4l | Linux community | ptp4l |
| tiny-lldpd | Linux community | tllpd |
| QoS tool | Microchip | qos |
| VCAP | Microchip | vcap |
| FP tool | Microchip | fp |
| PSFP tool | Microchip | psfp |
| FRER | Microchip | frer |

**Note 1:** The Microchip provided tools show the syntax when ran without parameters.

Table 2 lists a set of debug tools:

**TABLE 2: DEBUG TOOLS**

| Name | Origin | Example |
|---|---|---|
| Debug messages | Linux community | dmesg |
| Packet capture | Linux community | tcpdump |
| Packet injection and capture | Microchip | ef, ef-loop |
| ProcFS and DebugFS | Microchip | cat /proc/...<br>cat /sys/kernel/info/... |
| Symbolic register access | Microchip | symreg |


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## APPENDIX A: INSTALLING THE BSP

To install the BSP:

1. Go to http://mscc-ent-open-source.s3-website-eu-west-1.amazonaws.com.
2. Click the **bsp/** key link.
3. Locate http://mscc-ent-open-source.s3-eu-west-1.amazonaws.com/public_root/bsp/mscc-brsdk-arm-2022.06.tar.gz and download the file.
4. Unpack the file using:

```
$ mkdir -p /opt/mscc
$ tar xzf mscc-brsdk-arm-2023.06.tar.gz -C /opt/mscc
```

5. Download and install the toolchain:
   a) Determine the version of the toolchain to download. In `opt/mscc/mscc/mscc-brsdk-arm-2023.06/sdk-setup.mk`, the version of the toolchain file is 2023.02-101; hence, `mscc-toolchain-bin-2023.02-101.tar.gz` should be installed.
   b) On the page, http://mscc-ent-open-source.s3-website-eu-west-1.amazonaws.com, click **toolchain/**.
   c) Download `mscc-toolchain-bin-2023.02-101.tar.gz`.
   d) Install the downloaded file with:
   `$ tar xzf mscc-toolchain-bin-2023.02-101.tar.gz -C /opt/mscc`

**Note 1:** The documentation for the BSP is located in the path *bsp/mscc-brsdk-doc-2023.06.html*. In the document, go to *Supported HW>LAN966x* to find the details related to LAN966x.

**2:** The related source code is located in the path *bsp/mscc-brsdk-source-2023.06.tar.gz*. From this, the BSP can be built and variations of it can be made. See the BSP documentation (*bsp/mscc-brsdk-doc-2023.06.html*) for descriptions.

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## APPENDIX B: APPLICATION NOTE REVISION HISTORY

**TABLE B-1: REVISION HISTORY**

| Revision Level & Date | Section/Figure/Entry | Correction |
|---|---|---|
| DS00004826B (09-19-23) | All | Updated reference links. |
| | | Updated links, file paths, and software versions for the board support package. |
| | | Removed “Microchip Confidential” markings from the footer and made minor formatting changes. |
| DS00004826A (11-29-22) | Initial release | |


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