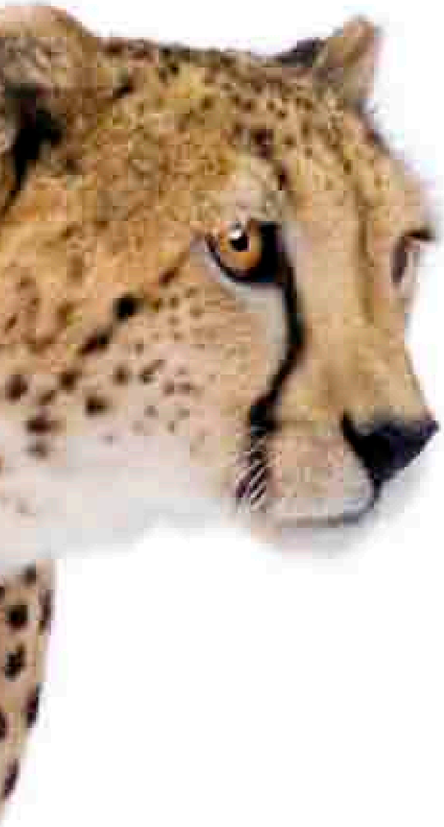
Impressive communication accelerator

In today's communication networks, shorter delays for Ethernet frames can be very significant. As measurements prove, HARTING Fast Track Switching (FTS) offers distinct advantages over conventional EtherNet switching solutions.

In order to guarantee real-time function in a network and consequently avoid any malfunctions, the frame delays should be as short as possible and the communications should be deterministic. A comparison of HARTING Fast Track Switching and conventional switching technology (a commercially available managed PROFINET switch) was made in the HARTING Test Laboratory (CTS) by measuring delays on two switch types and on a linear topology.

Two distinct switching technologies found in network technology are Store & Forward and Cut-Through. Many Industrial Ethernet switches work in Store & Forward mode, in which the incoming frames are temporarily stored in the switch before being forwarded. In Cut-Through technology, the frame is transmitted



as soon as the destination address has been recognized. HARTING Fast Track Switching identifies automation frames (such as PROFINET), gives them priority over IT frames, and forwards them in Cut-Through mode.

The different switching technologies can be compared by determining the latencies. This parameter, which describes a frame's dwell time in a switch, is defined in the technical documents RFC 2544 and RFC 1242.

SINGLE DEVICE LATENCY

In a comparison measurement, the latency for the minimum and maximum frame lengths of 64 bytes and 1,518 bytes was examined (see Table 1). The parameters used for all measurements were a data rate of 100 Mbit/s, a cable length of a maximum of eight meters, bidirectional data traffic and use of the bit forwarding method for measuring the latency. FTS technology reduced the latency for 64 bytes to virtually half that with Store & Forward technology, using a commercially available PROFINET switch as an example. The latency is furthermore independent of the frame length with FTS.

FRAME DELAY IN THE NETWORK

The frame delay in a network depends on parameters such as the latency, number of switches in use, network load, frame length, data rate, topology, number of users and cable length. Measurement configurations with two or eight devices in a linear topology were selected in order to examine these parameters.

With these configurations, a case study was reproduced in which a controller (e.g., PLC) accessed an actuator (e.g., a drive), while at the same time, an office application ran across the same network path (see Figure 1). The shorter frames typically used in automation technology can be delayed here by longer IT frames.

A comparison can be made of the Store & Forward technology and Fast Track Switching on a configuration with FTS devices because FTS works in Store & Forward mode if no automation frames are sent to the switch.

The measurement involved sending short frames with 64 bytes over a port, and feeding in long frames with 1,518 bytes over a second port. Because the frame delay depends on the traffic, there was a differentiation between minimum and maximum throughput. The data traffic at the input was chosen in such a way as to reach a maximum throughput of 100 % at the output of the first switch (Figure 2). The throughput consequently resulted from an approximately 5 % load of the port with 64-byte packet lengths and an approximately 95 % load of the port with 1,518-byte packet lengths.

The abbreviations P and I that are used (Figure 2) stand for the Preamble (8 bytes) and the Interframe gap (minimum 12 bytes) defined in the Ethernet standard. The minimum throughput was attained by enlarging the Interframe gap at the port with the long frames (partial load virtually 0 %). The conditions at the port with the short packets were not changed. This resulted in a throughput of approximately 5 %.

CONDUCTING THE EXPERIMENT

First the experiment was conducted with unaccelerated or standard frames, so that the conditions of Store & Forward are given very generally. (The frame delays for the short 64-byte packets are shown in Figure 3.)

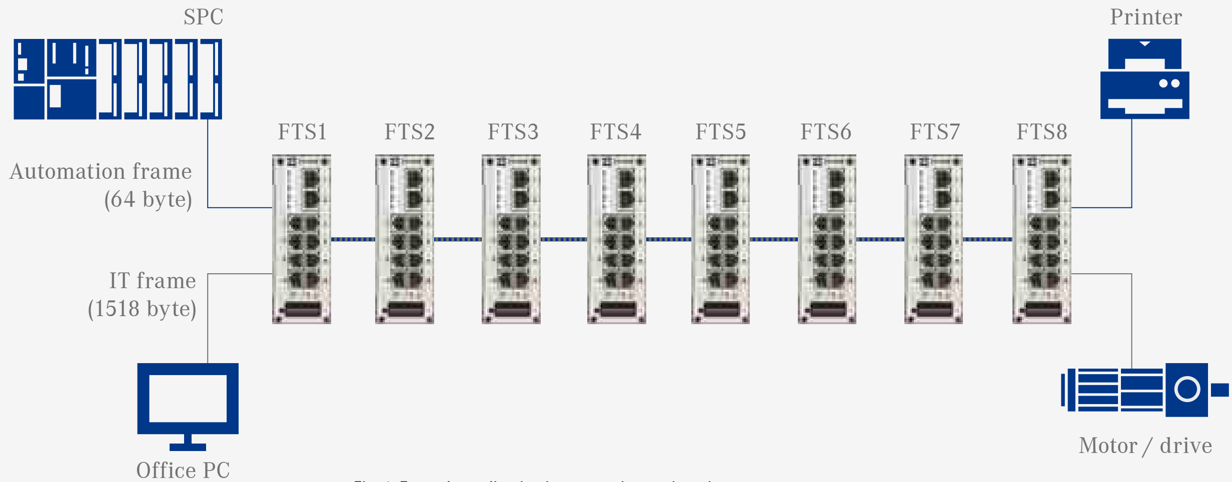


Fig. 1: Example application in automation engineering

The large spread in the cumulative latencies between the minimum and maximum throughput is especially clear. The maximum measured frame delay in Store & Forward mode, at 887.6 µs, is very noticeable. This time is caused by the 1,518-byte frames. When leaving the switch, the long packets seize the output port for approximately 123 µs, so that the short packets are delayed a number of times. Because this bottleneck does not occur at the last switch, this delay is encountered a maximum of seven times. A response curve with a relatively low throughput of 35 % was also recorded. The average frame delay established here for eight devices is already 825.5 µs. This means that in an actual application, short frame delays are rarely possible with Store & Forward.

The experiment also involved sending automation frames to the 64-byte port. The FTS recognized and accelerated these. As before, long IT frames were sent to the other port. The frame delays were again measured for the two cases with maximum and minimum throughput.

As Figure 3 shows, the spread of the frame delay was considerably reduced. The maximum frame delay for eight switches was reduced from 887.6 µs in Store & Forward mode to 45.1 µs. This was possible because FTS technology allows the automation frames to pass ahead.

THE RESULT

The measurement result shows Fast Track Switch's clear advantages: Using HARTING Fast Track Switching, the latency for short frames is only half of the latency found when a conventional managed PROFINET Conformance Class B switch is used. And it is independent of the frame length.

In an example application with eight switches in linear topology, it was proven that FTS technology transmits frames considerably faster than Store & Forward does. The Fast Track Switch significantly reduces the Store & Forward's delay spread, which is strongly dependent on the network load.

OUTLOOK

Management functions and the PROFINET IO stack do not influence the examination of the performance. The PROFINET IO stack does, however, offer the advantage that the engineering tool allows users to see, configure and diagnose the switch. In the next step, HARTING will also be offering managed FTS switches that offer the PROFINET IO stack in addition to diverse management functions. The PROFINET IO stack will simplify the configuration and diagnosis of devices within a PROFINET environment. The switches are integrated into the device libraries via the standardized GSD file in the configuration tools for network project planning, such as Siemens Step 7. During operation, diagnoses that arise are transferred to the control environment in a standardized form, making them available to users in the familiar way.

> "The idea of a convergent Ethernet network from the control level to the field level has become reality."

These conveniences simplify the work with components without influencing the performance. In combination with the performance-enhancing, integrated Fast Track Switching technology, a communication system with Standard

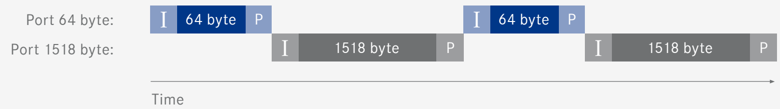


Fig. 2: Load configuration with 100% transfer rate

Switch type	Switching technology	Latency period (µs) at 1xDUT	
		64 byte	1518 byte
HARTING FTS 3100s-A	Fast Track Switching	4.6	4.6
Competitor switch, PROFINET Conformance Class B	Store & Forward	8.7	124.7

Table 1: Latency periods at a switch

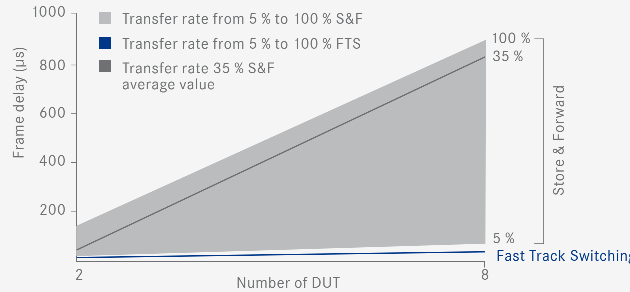


Fig. 3: Frame delay as a function of the number of switches, transfer rate and switching technology for 64-byte packets

Ethernet will now also meet the field level requirements. Consequently, the idea of a convergent Ethernet network, from the control level to the field level, has now become a reality. HARTING is rigorously pursuing these user-oriented concepts with its Automation IT portfolio. ■

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