Unified Communication Framework

Dominic Gaisbauer[1], Yunpeng Bai[1], Stefan Huber[1], Igor Konorov[1], Dymitro Levit[1], Stephan Paul[1], and Dominik Steffen[2]

***Abstract*—The Unified Communication Framework is a unified network protocol and FPGA firmware for high speed serial interfaces employed in Data Acquisition systems. It provides up to 64 different communication channels via a single serial link. One channel is reserved for timing and trigger information whereas the other channels can be used for slow control interfaces and data transmission. All channels except the timing are bidirectional and share network bandwidth according to assigned priority. The timing channel distributes messages with fixed and deterministic latency in one direction. In this regard the protocol implementation is asymmetric. The precision of the timing channel is given by the jitter of the recovered clock and is typically in the order of 10-20 ps RMS. The timing channel has highest priority and a slow control interface should use the second highest priority channel in order to avoid long delays due to high traffic on other channels. The framework supports point-to-point connections and star-like 1:n topologies for optical networks with a passive splitter. It always employs one of the connection parties as a master and the others as slaves. The star-like topology can be used for front-ends with low data rates or pure time distribution systems. In this case the master broadcasts information according to assigned priority whereas the slaves communicate in a time sharing manner to the master. In the OSI layer model the Unified Communication Framework can be classified as layers one to three which includes the physical, the data, and the network layer.**

***Index Terms*—DAQ, Fixed Latency transmission, FPGA, Optical transmitters, Slow Control, Transport protocols.**

I. Unified Communication Framework

The UCF is originating from *Synchronization Of Data Acquisition* (SODA) time distribution system developed by [1] and is applied to the *Precision Experiment on Neutron Lifetime Operating with Proton Extraction* (PENeLOPE) experiment [2]. It was then further extended to support many different experiment topologies shown in figure 1. As can be seen from this figure the topologies reach from single and multiple point to point connections to single or multiple star-like topologies. The framework uses the 8b/10b encoding scheme and 10b K-characters within its transport layer protocol for establishing the connections between the UCF slave(s) and master(s). On master and slave side firmware user interfaces (FUIs) are provided for data transmission which are based on the ARM AMBA AXI protocol specifications [3]. In the following sections the framework is described from the low level to the high level interface.

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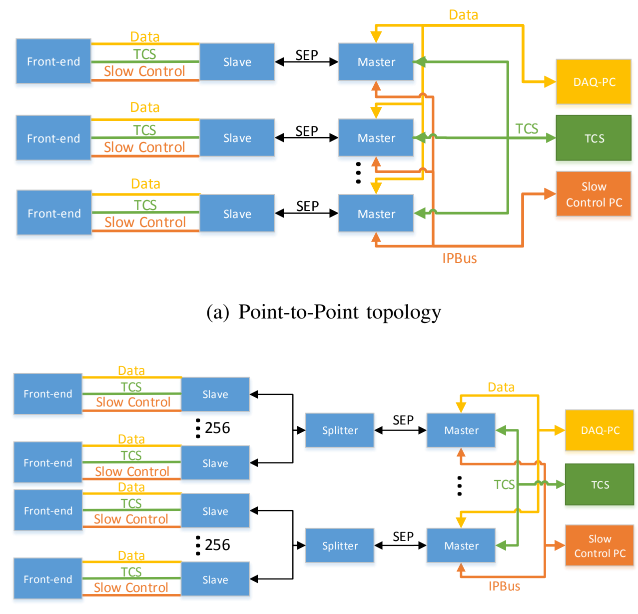
[1] Department of Physics, Institute for Hadronic Structure and Fundamental Symmetries, Technische Universitt Mnchen, James-Franck-Strasse 1, 85748 Garching, Germany e-mail: d.gaisbauer@tum.de

[2] CERN, 385 Route de Meyrin, 1217 Meyrin(Geneva), Switzerland



(a) Point-to-Point topology

(b) Hybrid topology

Fig. 1. Scheme of a typical UCF configurations.

II. Tests and Results

A. Set-Up

In order to test the framework a small set-up with an FPGA card holder was manufactured which is shown in figure 2. On the lower level of the set-up twelve slave cards are mounted and on the top level the passive optical splitter and the master are assembled. With the shown set-up the systems behaviour under different environmental situations and the long term behaviour was successfully tested. Furthermore the link utilization efficiency and transmission of JTAG protocol via UCF was tested.

B. JTAG, IPBus and data channels

In order to test the frameworks capability different interfaces and channels were sent via the optical link. This includes the IPBus protocol [4] as well as JTAG and data packets. The data transmission was tested up to a rate of 2.50 Gbit/s. In between the data frames IPBus messages were inserted in order to test the system with several channels arriving on the master or slave side. Overall the set-up passed all tests and all channels could be successfully transmitted. One additional comment should be made for the JTAG. It is possible to send it via the UCF but only with slow frequencies of about 100 kHz. In

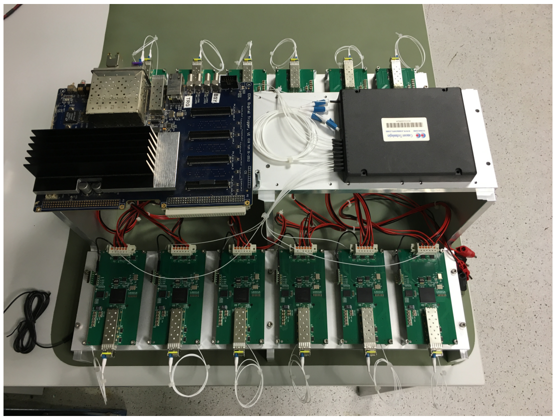


Fig. 2. Test set-up for framework tests.

other cases the delays between the different JTAG signals are to big.

C. Link utilization efficiency

The link utilization efficiency of the set-up was determined with twelve attached slaves having equal load. In order to calculate the efficiency the dead time of the system was measured. Dead time in this case means the time the master needs to switch from on slave to another - 16 μs for this set-up. Figure 3 shows some example measurements of the locking time. Having determined the switching time needed by the master the link utilization efficiency depending on the transmission time of each slave can be calculated and is shown in figure 3.

Transmission time [μs]	**Efficiency[%]**
25000	99.93
10000	99.84
1000	98.42
500	96.90
100	86.20
Measurement	**Transmission time [μs]**
1	15
2	16
3	17
4	15
5	17

Fig. 3. Link utilization efficiency of the link with different transmission times and locking time.

III. Conclusion and Outlook

Overall the unified communication framework developed provides up to 64 different communication channels with only one single optical fiber and various user definable link speeds. Depending on the topology chosen (either 1:n or multiple 1:1) the framework operates in a time sharing manner providing a fixed latency transmission for one of the 64 communication channels. This can be used e.g. for trigger distribution. The precision of this channel is mainly depending on the recovered clock jitter which is in the order of 10-20 ps RMS. If the framework is used in a star-like topology the master needs 16 μs for switching from one slave to another. The link utilization efficiency of the protocol is typically in the order of 98 to 99 % depending on the architecture. Furthermore it is also possible to establish a JTAG connection via the framework with JTAG chain speed of 100 kHz.

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