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40MHz trigger-less readout of the CMS Drift Tube muon detector

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The Level-1 trigger scouting system of the CMS experiment aims at intercepting intermediate data produced by the L1 trigger processors, before the final trigger decision.
This system can be complemented by adding the raw stream of data collected from the detector front-end, where the throughput is manageable. An implementation of the triggerless readout is realized by reading a sector of the CMS Drift Tubes detector, which has been equipped with the preproduction of Phase-2 upgrade front-end boards. A Xilinx VCU118 acts as a concentrator of the Phase-2 demonstrator lpGBT links and transmits data to a server via 100G TCP/IP.

Summary (500 words)

The 40 MHz L1-trigger scouting project of the CMS experiment aims at capturing intermediate data produced by the L1 trigger processors at the full bunch crossing rate, to perform online analysis independently of the final trigger decision. The system works as a parallel readout chain that processes copies of the streams between the L1 trigger boards, which are obtained via spare optical links. The data is then concentrated using commercial FPGA development boards and transmitted to dedicated computing resources.
The stream of L1 trigger primitives can be complemented with the raw stream of data collected from detector front-end boards, when the throughput is manageable for the links bandwidth and computing resources. This would enable the reconstruction of physics processes without the bias introduced by the L1 trigger, on top of real-time diagnosis of the detector status.
The CMS Drift Tubes (DT) muon detector offers a perfect candidate for the implementation of a triggerless-readout system thanks to its low occupancy. One of the sectors has been equipped with phase-2 front-end boards, the OBDT (On detector Board for the Drift Tube chambers), which digitizes the front-end signals and transmits them to the L1 trigger boards via high-speed optical links using the lpGBT protocol. Using spare links in the OBDTs, a copy of the data is sent also to the 40MHz DT scouting system. A commercial evaluation board, the Xilinx VCU118 evaluation board, is used to collect the front-end links. The receiver has been implemented using the CMS EMP firmware framework which contains an FPGA implementation of the lpGBT decoder and necessary components for interfacing with the CMS Timing and Control Distribution System (TCDS). Input streams from the lpGBT links are merged into frames and transmitted to dedicated servers via 100G TCP/IP links, implemented using a scalable network stack for FPGA developed by ETH. This framework was chosen as, in addition to TCP/IP and UDP/IP implementations it supports ROCEv2 (RDMA over Converged Ethernet), the target protocol for this system. In this scenario, the current TCP/IP implementation is used as a starting point of the development and for performance comparisons with ROCE.

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