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A TTC Upgrade Proposal Using Bidirectional 10G-PON FTTH Technology

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A new generation FPGA-based Timing-Trigger and Control (TTC) system based on emerging Passive Optical Network (PON) technology is being proposed to replace the existing off-detector TTC system used by the LHC experiments. High split ratio, dynamic software partitioning, low and deterministic latency, as well as low jitter are required. Exploiting the latest available technologies allows delivering higher capacity together with bidirectionality, a feature absent from the legacy TTC system. This article focuses on the features and capabilities of the latest TTC-PON prototype based on 10G-PON FTTH components along with the metrics characterizing its performance.

Summary

The Timing-Trigger and Control (TTC) system is a crucial system dedicated to synchronization of experiment electronics to the LHC beam. Currently, it is a unidirectional network extensively deployed in all major detectors distributing the LHC bunch clock and the level-1 trigger accept decision (L1A) as well as individually addressed or broadcast commands to the various detector sub-partitions. To match the needs for increased payload capacity and to provide bi-directionality, a feature absent from the legacy TTC, a new generation TTC system is being investigated for off-detector use, based on Passive Optical Network technology (PON). A PON is a bidirectional (but single fibre) point-to-multipoint network architecture in which optical splitters are used to enable a master node or Optical Line Terminal (OLT) to communicate with up to 128 slave nodes or Optical Network Units (ONUs). It is based on already mature devices, as the PON is nowadays the most successful solution worldwide for deploying FTTx networks. A first TTC-PON demonstrator was built in 2010 during early investigations made at CERN, using commercial FPGAs and 1-Gigabit Ethernet PON transceivers. The first and very promising results motivated the work to explore the emerging XG-PON technology in order to better fit the user requirements in terms of latency and payload. Based on the backbone of the first TTC-PON demonstrator, a second demonstrator using 10G-PON devices was developed to include all the features of its predecessor with enhanced performance. In addition, it introduces some new features: dynamic software partitioning targeting up to 128 nodes per network tree; large downstream payload; low downstream trigger latency; and embedded throttle/busy signals on the upstream path with bounded latency.
The present phase of the TTC-PON project consists of tuning the 10G-PON technology to match our requirements. The protocol of the downstream path is optimized to allow fixed and low latency delivery of recovered clock as well as trigger and trigger types. On the upstream direction, all the parameters of the Time Domain Multiplexing protocol are being pushed to their limits in order to increase the individual bandwidth of each node and reduce the waiting time of busy/throttle signals. To be able to measure the impact of each parameter on the network quality, a detailed set of characterization methods and metrics has been carefully chosen.
This article focuses on the features and capabilities of this new TTC-PON along with the metrics characterizing its performance, aiming to commission a first prototype within an experiment and test it onsite in 2015.

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