Contribution ID: **108** Type: **Oral**

Passive Optical Networks in Particle Physics Experiments

Thursday 24 September 2009 11:50 (25 minutes)

In this paper we propose a generic Passive Optical Network (PON) platform for the distribution of synchronous, fast rate signals within particle physics experiments. Our aim is to demonstrate a versatile network architecture that will be able to serve one or more applications in future high energy physics (HEP) experiments. In order for the current PON systems to be adapted to future HEP optical link requirements, a number of challenges regarding the physical layer and medium access layer implementations have to be overcome. A prototype PON is in the process of being built and its properties in accordance to HEP tentative requirements will be measured and reported.

Summary

Passive optical networks have attracted considerable attention from the telecommunications community over the past decade as they are considered to be the most cost efficient solution for fiber-to-the-home applications, [1-2]. In its simplest form a PON consists of a central node which is called the Optical Line Terminal (OLT), connected to a number of customer terminals called Optical Network Units (ONUs) through a passive optical tree. Communication between OLT and ONUs is bidirectional and occurs through the same fiber by employing different wavelengths for the OLT to ONU (downstream) communication and the ONU to OLT (upstream) communication. A simple optical filter installed at the OLT and at each of the ONUs is responsible for separating the upstream from the downstream signals on both sides of the network. PONs use Time Division Multiplexing (TDM) to prevent collisions from multiple ONU transmissions and they utilize a centralized architecture where all processing and decisions as to how medium should be shared is concentrated at the OLT, while ONUs are kept very simple.
A number of applications in LHC are currently using similar point-to-multipoint passive architectures such as the global clock distribution [3], and the Timing,Trigger and Control (TTC) systems [4]. These applications will require higher bandwidths and enhanced functionalities in the S-LHC and other future HEP experiments and therefore, we believe that they can benefit from the PON concept. In addition, even some applications which are currently of point-to-point in nature, such as the Data Acquisition (DAQ) system [5], might also benefit from certain aspects of PONs. The main advantages that PON technologies can bring to HEP applications are:
a) They are inherently bidirectional networks.
b) A number of protocols have already been developed and standardized for channel access arbitration, synchronization and path protection.
c) If they are used instead of point-to-point applications they can reduce the number of components installed and thus maintained in the system, as well as the fiber optic cabling.
d) Keeping track of PON technology can provide us with information about a pool of high bandwidth, cheap optical transceiver components that might be used even in non-PON architectures.
Despite their benefits, implementation of PONs in particle physics experiment environments is not straightforward. PON components and protocols have been primarily designed to serve commercial applications, such as to deliver voice and video data, but different requirements will need to be met for them to be employed in HEP. More particularly PONs need to be modified in the following ways:
1) Protocols have to be adjusted to ensure that signals are transmitted with very low latency usually within a few tens of clock cycles. For comparison, today's most latency demanding PON application is voice transmission with latency requirement in the order of 1ms. In addition, signals must have a well defined and fixed latency which should not vary with time due to environmental or other changes, for example.
2) Signals must be delivered to their destinations with very low jitter, typically in the order of a few hundred ps, as jitter uncertainties accumulate and might eventually result to system loosing synchronization.
3) A generic architecture should be able to support multiple data rates to be able to support multiple applications.
4) Hardware must be radiation hard if PONs are to be deployed at the front-end.

This paper will present the results of prototype demonstrators based on commercially available PON transceivers and FPGAs that are being built and tested against jitter and latency requirements for HEP applications. In addition, modified PON protocols for the communication between the various terminal components in such networks will be discussed.

[1] D. Kettler et. al., "Driving fiber to the home,"IEEE Comm. Mag. pp. 106-110, Apr. 2000.
[2] A. Cauvin et. al. "Common technical specification of the G-PON system among major worldwide access carriers,"IEEE Comm. Mag., pp. 34-40, Oct. 2006.
[3] K. Bunkowski et. al., I. S. Jacobs and C. P. Bean, "Synchronization methods for the PAC RPC trigger system in the CMS experiment,"Meas. Sci. Technol., vol. 18, pp. 2446–2455, Jul. 2007.
[4] Available online, http://ttc.web.cern.ch/TTC/.
[5] M. Niculescu et. al. "The data-flow system of the ATLAS DAW and event filter prototype −1 project". In Proc. Int. Conf. on Accelerator and Large Experimental Physics Control Systems, Trieste, Italy, 1999.

Primary author: Dr PAPAKONSTANTINOU, Ioannis (CERN)

Co-authors: Dr SIGAUD, Cristophe (CERN); Mr SOOS, Csaba (CERN); Dr VASEY, Francois (CERN); Prof. DARWAZEH, Izzat (University College London); Dr TROSKA, Jan (CERN); Dr MITCHEL, John (University College London); Mr SANTOS, Luis (CERN); Mr MOREIRA, Paulo (CERN); Mr STEJSKAL, Pavel (CERN); Dr BARON, Sophie (CERN); Mr PAPADOPOULOS, Spyridon (CERN); Dr DETRAZ, Stephane (CERN); Mr SILVA, Sérgio (CERN)

Presenter: Dr PAPAKONSTANTINOU, Ioannis (CERN)

Session Classification: Parallel Session B5 - Optoelectronics and Links

Track Classification: Optoelectronics and Links