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Trigger Platforms for CMS at the SLHC

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CERN has made public a comprehensive plan for upgrading the LHC accelerator to provide increased luminosity commonly referred to as SuperLHC (SLHC). The plan envisages two phases of upgrades during which the LHC luminosity increases gradually to reach 6-7×1034 cm-2sec-1. Over the past year CMS has responded with a series of workshops and studies which have defined the roadmap for upgrading the experiment to cope with the SLHC environment. Increased luminosity will result in increased backgrounds and challenges for CMS and a major part of the CMS upgrade plan is a new Level-1 trigger system which will be able to cope with high background environment at the SLHC. Two major CMS milestones will define the evolution of the CMS trigger upgrades: The change of the Hadronic Calorimeter electronics during phase-I and the introduction of the track trigger during phase-II. This paper outlines different alternative designs for a new trigger system. In particular, it looks at different algorithms and how they might be best implemented on different hardware platforms and the consequences for cost, latency, complexity and flexibility. The hardware platforms used to evaluate the performance of the algorithms are based on Xilinx V5 FPGAs.

Summary

Plans are already well advanced for upgrades to the LHC machine that will provide increased luminosity. The current CMS experiment will fail to reap the full benefit of these upgrades for a number of reasons. One of these is that the current trigger system will be overwhelmed. It will not be possible to set sensible energy thresholds without the trigger rate exceeding the maximum L1A rate of 100kHz. Hence the Global Trigger would be forced to restrict the trigger rate by simply pre-scaling the trigger and thus effectively negating any benefit from increased luminosity. It is for this reason that work has started on trying to integrate a tracking trigger in a future trigger system.
This would help identify the most interesting events and bring the trigger rate back below 100kHz. A new trigger system could potentially have several others benefits such as improved flexibility because it would be based solely on FPGAs. It could also be much simpler and thus be easier to design, build and maintain, which could have a substantial impact not just in the cost of the hardware, but also on the manpower cost to test and operate it.

The upgrade of the Hadronic Calorimeter (HCAL) electronics will precede that of the tracker and will provide lateral information of the energy depositions within the HCAL already at phase-I. An upgraded trigger system implemented at the same time as the HCAL upgrade would provide improvements to cluster based triggers such as the tau trigger while at the same time prepare the trigger to receive tracking trigger information. This will enable CMS to make more stringent isolation cuts and provide triggers of higher purity early in the upgrade program.

Consequently, the time seems ripe to begin consideration of a new trigger system that would take advantage of the latest advances in programmable technology and high speed serial interconnects. This paper outlines various alternatives for a new trigger system. In particular, it looks at different algorithms and how they might be best implemented in a real system and the consequences for cost, latency, complexity and flexibility. It also reflects on both the good and bad decisions made in the current Global Calorimeter Trigger and its predecessor.

The Optical Global Trigger Interface card (OGTI) has been designed and produced to replace the high speed serial copper links between GCT and GT. As such it represents the first upgrade to the calorimeter trigger system. It is based upon a Xilinx Virtex 5 LX110T with 16 bi-directional optical links running at up to 3.2Gb/s. It has a large parallel interface of 320 I/O in a dual CMC form factor. Results on the performance of the OGTI are presented. The optical link and FPGA technology of this card is similar to the technology that will be used at the SLHC trigger. For this reason the OPTO GTI is used here as a test platform for several of the triggering schemes and algorithms in this paper as well as for investigations in optical link technology.

To avoid reinventing the wheel in each sub system there are several areas where it might be useful co-operate. An area worthy of cooperation, or perhaps standardisation, would be on a simple high speed serial link protocol that would allow different systems to automatically lock the link to a particular latency and verify the integrity of the data. An example of this exists within the GCT and it includes a CRC check, however the protocol will be reviewed in light of experience gained over the last few years.

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