Applications of programmable logic in modern particle physics experiments

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Abstract

The newest generation of particle physics experiments is in the final stages of construction in CERN, Geneva in preparation for data taking at a new accelerator, the Large Hadron Collider (LHC), which will be the world's highest energy machine. These experiments are immensely challenging to build for several reasons and rely heavily on their electronic systems, which are as advanced as the rapid pace of technology evolution will permit. Most of each experiment will be subjected to intense radiation fluxes from the unprecedented rate of interactions between the beams of colliding protons, and to study the new physics which is expected to be discovered, rare events need to be captured for complete analysis in an unbiased way. However, most of the data registered by the detectors must be discarded, simply because the volume and rates are so high that the computer systems cannot record to permanent storage sufficiently fast. The ability to do select extremely rare events will be crucial to the success of the LHC physics programme. Recent developments of FPGA devices have been exploited to maximise the flexibility and power of the data analysis systems which are being implemented. The motivation for the experiments and a brief summary of the most important detector systems of one of them, CMS - the Compact Muon Solenoid experiment - will be presented, with more detailed explanations of some of the electronic systems and where, why and how programmable logic is so important to them.