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The Software Architecture of the LHCb High Level Trigger

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The LHCb experiment is a spectrometer dedicated to the study of heavy flavor at the LHC. The rate of proton-proton collisions at the LHC is 15 MHz, but disk space limitations mean that only 3 kHz can be written to tape for offline processing. For this reason the LHCb data acquisition system – trigger – plays a key role in selecting signal events and rejecting background. In contrast to previous experiments at hadron colliders like for example CDF or D0, the bulk of the LHCb trigger is implemented in software and deployed on a farm of 20k parallel processing nodes. This system, called the High Level Trigger (HLT) is responsible for reducing the rate from the maximum at which the detector can be read out, 1.1 MHz, to the 3 kHz which can be processed offline,and has 20 ms in which to process and accept/reject each event. In order to minimize systematic uncertainties, the HLT was designed from the outset to reuse the offline reconstruction and selection code, and is based around multiple independent and redundant, selection algorithms, which make it possible to trigger efficiently even in the case that one of the detector subsystems fails. Because of specific LHC running conditions, the HLT had to cope with three times higher event multiplicities than it was designed for in 2010 and 2011. This contribution describes the software architecture of the HLT, focusing on the code optimization and commissioning effort which took place during 2010 and 2011 in order to enable LHCb to trigger efficiently in these unexpected running conditions, and the flexibility and robustness of the LHCb software framework which allowed this reoptimization to be performed in a timely manner. We demonstrate that the software architecture of the HLT, in particular the concepts of algorithm redundancy and independence, were crucial to enable LHCb to deliver its nominal trigger signal efficiency and background rejection rate in these unexpected conditions, and outline lessons for future trigger design in particle physics experiments.

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