Online physics-selection software in the ATLAS experiment at LHC

M. Pilar Casado, CERN

Introduction

The purpose of this study is the specification, design and development of online selection algorithms, and associated framework, for the second-level trigger of the ATLAS experiment, and their evaluation on a large-scale prototype.

The Atlas experiment

ATLAS (A Toroidal LHC ApparatuS) is a general-purpose physics detector which will operate at the Large Hadron Collider (LHC) in 2007. One of its main goals is to investigate the mechanism of mass generation of existing particles and to search for new physics beyond the Standard Model (SM). The detector will take data produced in proton-proton collisions at 14 TeV center of mass energy for design luminosity of 10^{34} $cm^{-2}s^{-1}$, beam crossings being 25 ns apart. A global view of the experiment is presented in Fig. 1. The detector is 22 meters high, 44 meters long, and the overall weight is about 7000 tons.

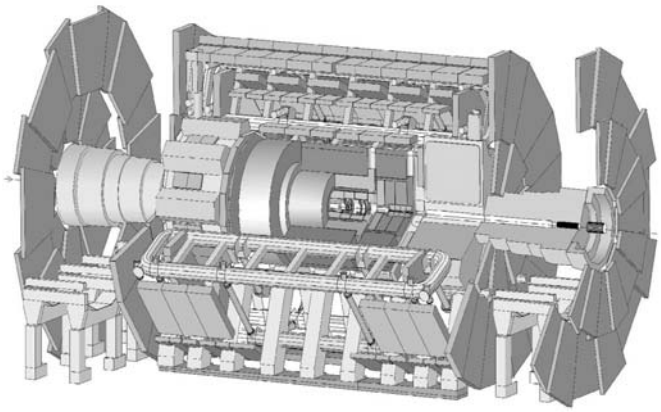

Fig. 1 Overall view of the ATLAS experiment.

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The Trigger system

The trigger system is an important part of the ATLAS detector which is the responsible of reducing the event rate at the LHC (~10^9 Hz) to a manageable level (~100 Hz) for data storage. In this reduction it is crucial to keep high efficiency for interesting signals while undesirable events are rejected. To meet this requirement, the ATLAS trigger system is foreseen as a three-level trigger. The first-level (LVL1) trigger is implemented in custom hardware, while the second-level (LVL2) and third-level (LVL3 or Event Filter, EF) triggers (together referred to as High Level Triggers, HLT) are implemented as computing farms interconnected by high-speed networks using commodity components. Both LVL2 and the EF will execute complex software selection algorithms based on properties of interesting processes.

Triggering at LHC is significantly more difficult than at today's more advanced machines due to both the event rate and the event size. For the last decade, Research and Development (R&D) has been carried on for the Trigger and Data AcQuisition (T/DAQ) systems at LHC, and as a result of this work a logical architecture has been presented, supported by various implementation studies [1].

Many important decisions for the ATLAS T/DAQ project are being taken now using a realistic large-scale prototype, which is flexible enough to evaluate different alternatives. The prototype is built on the work done in previous projects, and moreover the whole system is being integrated in subsequent phases for the first time. Initial tests have

already been carried out to study the functionality of the data collection and control software, and to investigate implementation options. In a subsequent step, HLT selection software is going to be added and assessed using simulated detector data. The results of this study will be a fundamental part of the T/DAQ Technical Design Report, foreseen for publication in 2003.

High Level Trigger physics-selection software

The physics-selection software is responsible for selecting interesting signals while background events are discarded. The correct design and implementation of this piece of the project is fundamental as it will not be possible to recover a rejected event. Therefore, the selection software, together with many other components of the experiment, determine the physics potential of the ATLAS detector.

The HLT selection software is formed by four main elements (see Fig. 2):

1. The HLT algorithms are used to process the event and obtain abstract objects such as electrons, jets and muons, which are the basis to make the trigger decision.
2. The Event Data Model covers all data entities in the event and their relationships with each other. The data entities span from the direct data taken from the detector to the most abstract objects used in physics analyses.
3. The Steering controls the selection software. It arranges the algorithm processing for the event analysis in the correct order.
4. The Data Manager handles the event data during the trigger processing.

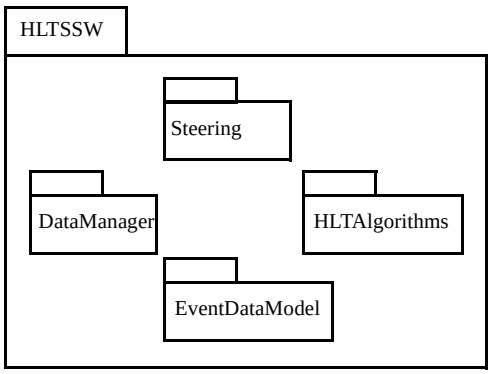

Fig. 2 Components of the HLT Selection Software.

The LVL2 and EF algorithms are developed in close collaboration with the Physics and Event-Selection Architecture (PESA) group of the ATLAS collaboration. In previous studies, only an heterogeneous set of algorithms was developed. Eventually a complete and coherent set of algorithms with realistic input data will be provided and assessed.

After the design and implementation of the selection algorithms in the prototype, the selection efficiency of the interested events will be studied as a function of the trigger output rate. Relevant detector properties will be taken into account, as for example thresholds of readout channels.

Conclusions

Very important elements of the ATLAS T/DAQ architecture are being defined now using a realistic large-scale prototype. Initial tests have already been carried out to study the functionality of the data collection and control software. In a subsequent step, HLT selection software will be added and assessed using simulated detector data. The results of this study will be a fundamental part of the T/DAQ Technical Design Report.

References

[1] ATLAS high-level triggers, DAQ and DCS Technical Proposal (CERN-LHCC-2000-17)