Run Control Communication for the Upgrade of the ATLAS Muon-to-Central-Trigger-Processor Interface (MUCTPI)


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ATLAS Experiment @ LHC

The ATLAS experiment is a general-purpose experiment at the Large Hadron Collider (LHC) at CERN. It observes proton-proton collisions at an energy of 13 TeV. With about 25 interactions in every bunch crossing (BC) every 25 ns, there are 10^6 interactions per second. The trigger system selects those events that are of interest to physicists, which reduces the event rate from a possible 1,000 kHz to a rate of about 1 kHz. The ATLAS trigger system consists of a Level-1 trigger based on custom electronics which reduces the event rate to a maximum of 100 kHz, and a high-level trigger system based on commercial computers which reduces the event rate to around 1 kHz.

Model #1: IPBus

IPBus is provided by the CMS experiment and is based on firmware and software. The firmware is implemented in the programmable part of the SoC, receives UDP packets, and performs read/write accesses on the processing FPGAs of the MUCTPI. Run controllers, i.e., run control processes, on a PC directly connected to the SoC use the software library µHAL. Note that for this model, the processor system of the SoC is not needed, and that it could be implemented in an FPGA.

Model #2: RemoteBus

RemoteBus was developed by the ATLAS LCTC team and is based on software using an approach like the "Remote Procedure Call". Run controllers on a PC directly connected to the SoC implement RemoteBus clients which send requests using TCP/IP to the RemoteBus server on the processor system of the SoC. A dedicated thread per client executes read/write accesses on the processing FPGAs of the MUCTPI or more complex functions for serial protocols like I²C, SPI, etc. Queuing of requests allows them to be executed in one go and mitigate latency overhead. C++ provides flexibility to extend the functionality. A minimal latency of 75 µs for a request-response transaction and sustained data rates of 50 MB/s have been measured.

Model #3: Run Controller

The ATLAS software for a run controller was ported to the embedded Linux by the LCTC team. The run controller runs on the processor system of the SoC and communicates directly with the ATLAS run control system using TCP/IP. Low-level software in the run controller performs read/write accesses of the processing FPGAs of the MUCTPI.

Summary

A System-on-Chip (Xilinx Zynq) has been used successfully to provide communication between the ATLAS run control system and the new MUCTPI. Several models of communication have been compared. An available UDP-based implementation uses firmware for the programmable logic, and although this was expected it uses an unreliable protocol and does not provide sufficient flexibility to extend its functionality to more complex operations on the MUCTPI. A software implementation of the "Remote Procedure Call" and running on the processor system with embedded Linux provides reliable communication, and its implementation in C++ provides the possibility to extend its functionality to more complex operations, like serial protocols to be executed on the processor system. Porting of the ATLAS run control to embedded Linux was achieved and provides the highest flexibility, removing the need for intermediate layers of software. All software developments for the operating system and the application software were successfully maintained using the framework of the Yocto Project.

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