Conclusion

- It is possible to implement similar timing system functionality using either an event-based synchronization layer or White Rabbit.
- The different synchronization facilities (interfaces) inside the FPGA firmware will have important implications on the timing system firmware architecture.
- The White Rabbit architecture will revolve around absolute time scheduling, whereas an event-based architecture will revolve around downstreaming precisely scheduled event triggers.

Introduction

- The timing system provides timing critical services to the control system, as shown in Fig. 1.
- Commercial off-the-shelf products typically require customization, which adapts them to the machines unique requirements.
- The synchronization layer is a commercial off-the-shelf product together with the fully or partially supplied firmware, see Fig. 2.
- The synchronization facilities (FPGA firmware interfaces) of two different synchronization layers, White Rabbit [1] and Micro-Research Finland [5], were reviewed, as it has direct implications on how the timing system can be implemented.
- As proof-of-concept a set of timing system services was implemented, interfacing the White Rabbit firmware, Fig. 3, provides a simplified architecture describing the implementation.
- Other timing systems studied were REDNET [2], SINAP [3] and GMT [4]. REDNET and SINAP are both event based timing systems, the former using MRF, GMT is based on White Rabbit.

Timing System Services

- First, there are the fundamental services, e.g., coordinated actions of devices throughout the facility and time stamping of events, i.e. triggers of actions and acquisitions of data samples.
- In addition, there are the machine specific services, e.g., the Virtual Accelerators concept given in [2], and real-time communication channels.
- Typical requirements for any timing system are the accuracy and precision of synchronized outputs. Each synchronization layer has its own characteristics, stemming directly from its conceptual design and implementation.
- The synchronization layer that gives the lowest timing system implementation complexity is recommended.

Synchronization Layer

- The synchronization layer is an abstraction layer that conceals the synchronization below the timing system.
- Synchronization can be made in two conceptually different ways: either a) ensure that there is equal propagation delay to all the receivers and let actions be executed immediately upon reception, or b) synchronize time (as in 12:00 o'clock) of all network nodes and distribute schedules in advance with actions and exact time of execution.
- All synchronization layers implement network-wide clock (as in digital oscillator) synchronization (frequency and phase) to ensure alignment of output signals on the receivers.
- Performance measurements available cannot be compared in a fair manner. In the future a dedicated test bed will be set up for comparison.
- One major difference is the network latency. In MRF the downlink fan-out latency is insignificant, since there is no routing, and the uplink is in the 100 - 200 ns range per concentrator [6]. In White Rabbit the latency per fan-out layer in both directions is in the 10 - 20 us range [7].

Results

- The implemented proof-of-concept timing system provides a set of fundamental services, e.g., delivering synchronized pulses at multiple timing receivers.
- The result of the comparison is that, even though the interfaces are widely different, similar services can be realized, although through different architectural approaches.
- All White Rabbit based timing systems must have output queues in the receivers since actions are received in advance, not immediately executed, like in event-based timing systems.
- Strict requirements for low latency and deterministic loop-back capability can exclude White Rabbit as a viable option.

References


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