

Development of an AXI protocol tracing solution for FPGAs

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Heterogeneous Systems with FPGAs



- Definition: A system where software interacts with an FPGA
- For this work, a Linux system was used with an FPGA card over PCIe



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Challenges for Heterogeneous Systems

- Challenges:
 - Identify slowdowns and bugs in multiple interactions can be hard
 - Complex interactions are hard to simulate
- Solution: Have a tool that can trace the entire system

Software Tracing



- LTTng under Linux
- Limitations for heterogeneous systems with FPGAs :
 - Does not provide a complete view

Hardware Tracing



- FPGA logic analyzers for signal recording (expensive in memory, limited in duration)
- Other continuous signal analyzers in literature
- Limitations for heterogeneous systems :
 - FPGA tracing does not give a complete view

Proposed Solution





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Tracer Controller



- Trace buffer
- Control registers
- Timestamp insertion



Probe Chain

- Trace multiple signals
- Combine events into a single AXI Stream
- Probe internal FIFO to support bursts





Software Flow

- Packet logging :
 - Convert data into CTF format
 - Format interpretable by Trace Compass
- Analyzed application :
 - FPGA: memory buffer accessible via AXI bus
 - Software: Read and write this memory
 - LTTng used to trace the software part





Experimental Setup

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FPGA on PCIe







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Challenges



- Event synchronization :
 - Differences between processor and FPGA clocks
 - Multiple clocks possible at FPGA level
 - Clock drift
- Impact on performance:
 - Need to assess the impact of tracing on the system
 - Provide a realistic view of system behavior

Clock Drift



- Milliseconds of drift accumulate over time
- Clock frequency may change over time
- Continuous synchronization is needed throughout the entire trace





Continuous Time Synchronization

- Periodic sync packet
- Time synchronization in post processing





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Conclusion



- Accomplishments:
 - Trace hardware events continuously and generate a CTF trace
 - Global view of software and hardware events in Trace Compass
 - Clock drift compensation

Next Steps



- Synchronization of multiple clocks
- Characterize performance impact
- Test the solution with a real-world application