Automatic Offloading to Cluster Accelerators

Ciro Ceissler, Ramon Nepomuceno, Marcio Pereira and Guido Araujo

ciro.ceissler@students.ic.unicamp.br, {ramon.nepomuceno, mpereira, guido}@ic.unicamp.br

Institute of Computing - UNICAMP

For more information

www.hardcloud.org

Objective

HardCloud seeks to ease the task of integrating programs to FPGA-based accelerators. In HardCloud programmers could take their original code add a few annotations and quickly evaluate if an FPGA accelerator is a suitable solution to a particular application.

Execution of a pre-compiled FPGA bit-stream

```
#pragma omp target device(HARP) map(to: X) map(from: Y)
#pragma omp parallel for use(hrw) module(loopback)
// Software version of the loopback hardware module.
for(int i = 0; i < n; i++) {
    Y[i] = X[i];
}
```

The clause **use(hrw)** specifies that the annotated code block will use a pre-designed hardware, e.g., **module (loopback)**, to do the computation instead of the C code following the annotation. The Clang/LLVM OpenMP 4.0 runtime was extended to enable the design of HardCloud.

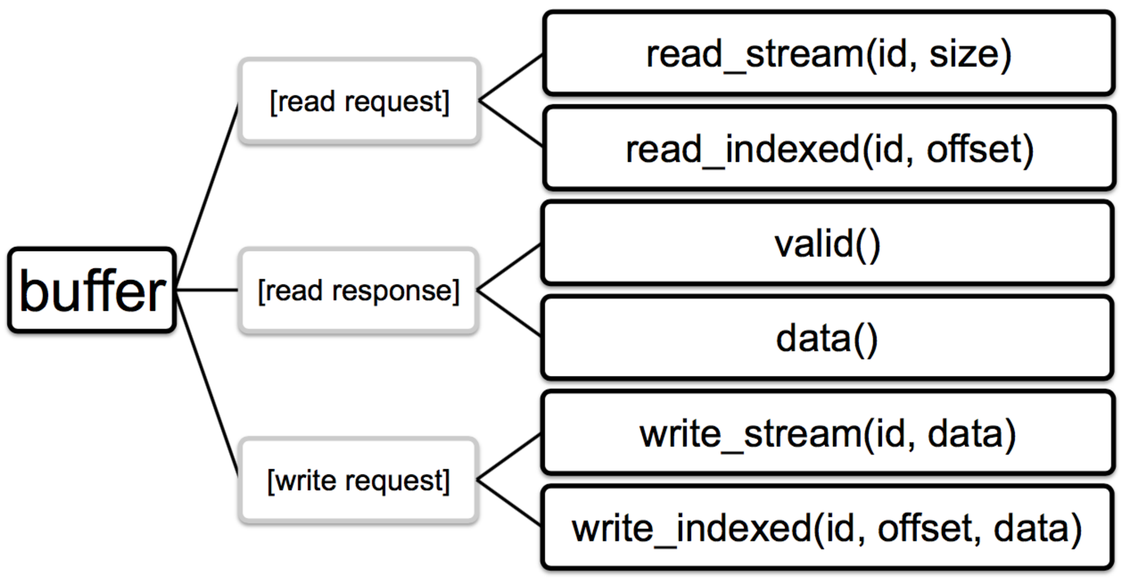
Hardware Interface

```
module IP (
  input  logic clk,
  input  logic rst,
  input  logic start,
  output logic finish,
  hc_buffer_if buffer
);

/* IP implementation */

endmodule : IP
```

Buffer Access Mode Functions



- **id:** buffer identifier
- **size:** data size in cache-lines
- **data:** one cache-line
- **offset:** displacement within buffer (indexed mode only)

Results

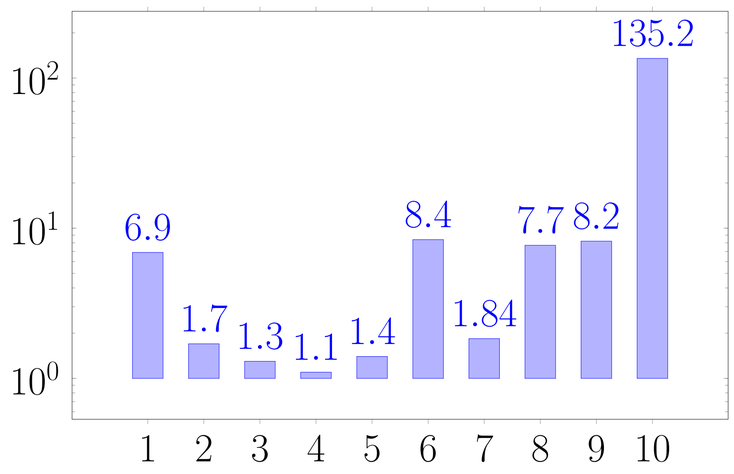
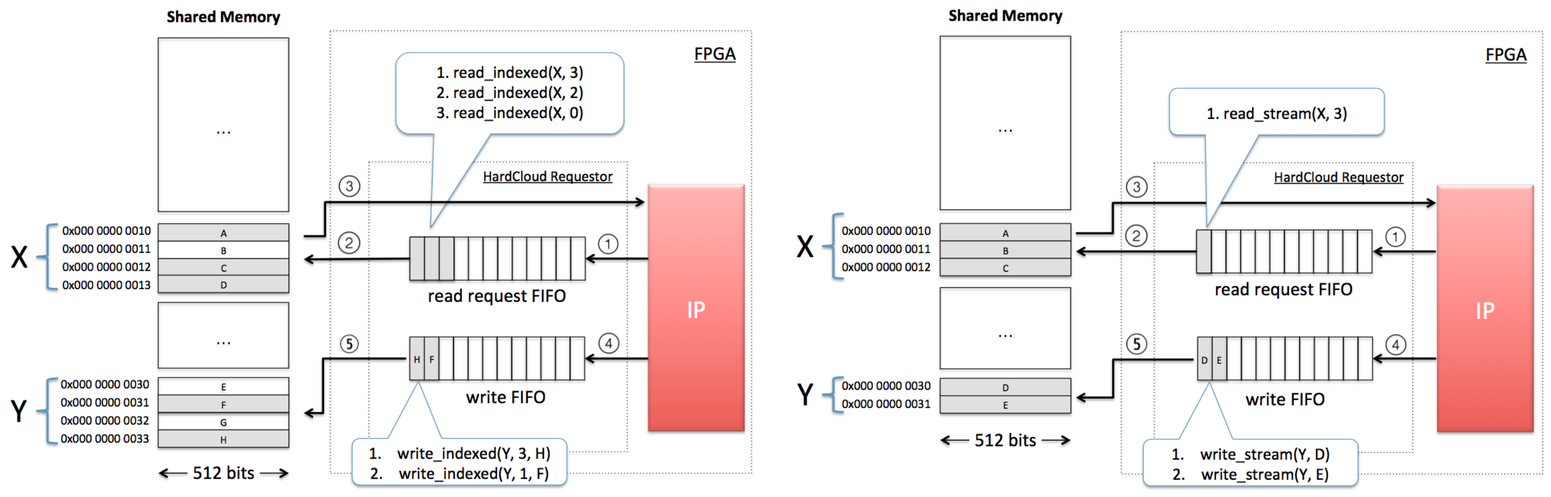


Figure 1: Logarithmic FPGA speedup over CPU

ID	Benchmark	Freq.	Send	Recv.
1	AES-128	200 MHz	1.2 GB	1.2 GB
2	SHA-512	200 MHz	1.2 GB	64 B
3	Sobel Filter	400 MHz	0.8 MB	0.8 MB
4	Gaussian Filter	400 MHz	3.1 MB	3.1 MB
5	MD5	200 MHz	1.2 GB	0.6 GB
6	FFT	200 MHz	1.2 GB	1.2 GB
7	Reed-Solomon Decoder	300 MHz	1.6 GB	1.5 GB
8	FIR Filter 40th Order	200 MHz	1.2 GB	1.2 GB
9	Smith-Waterman	200 MHz	64 MB	64 B
10	Gene Regulatory Network	200 MHz	0 GB	80 MB

Table 1: Benchmark runtime.

Access Modes



(a) Indexed Access Mode

(b) Stream Access Mode

Figure 2: Operation Modes Available

The HardCloud Interface provides an effortless method to connect the IP core by exchanging information with the OpenMP runtime and reading/writing the shared memory in a seamless way, through the CCI-P interface. Two operation modes are available: stream and indexed.

HardCloud Architecture

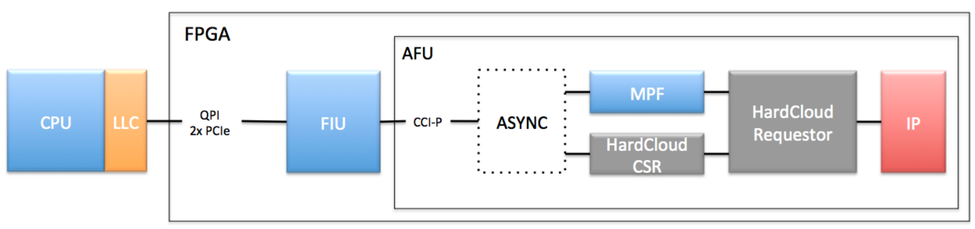


Figure 3: HardCloud Architecture

Highlighted in gray are the blocks developed to enable HardCloud. *HC_CSR* manages communication with the host, while *HC_Requestor* controls the flow of data to/from shared memory.

Acknowledgements

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