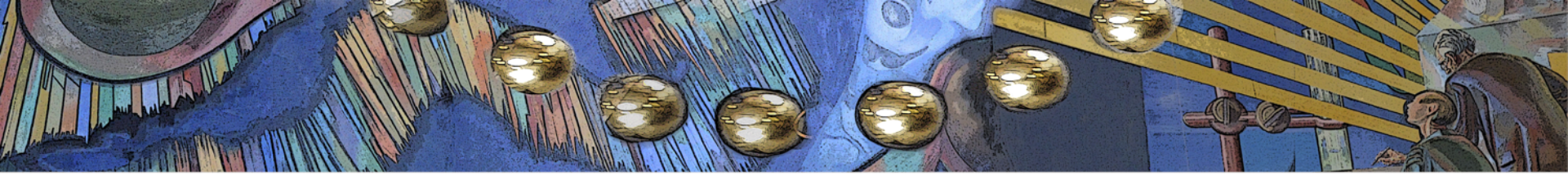
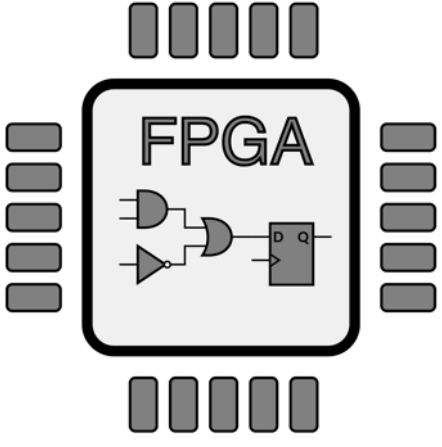


UiO : Department of Physics
University of Oslo



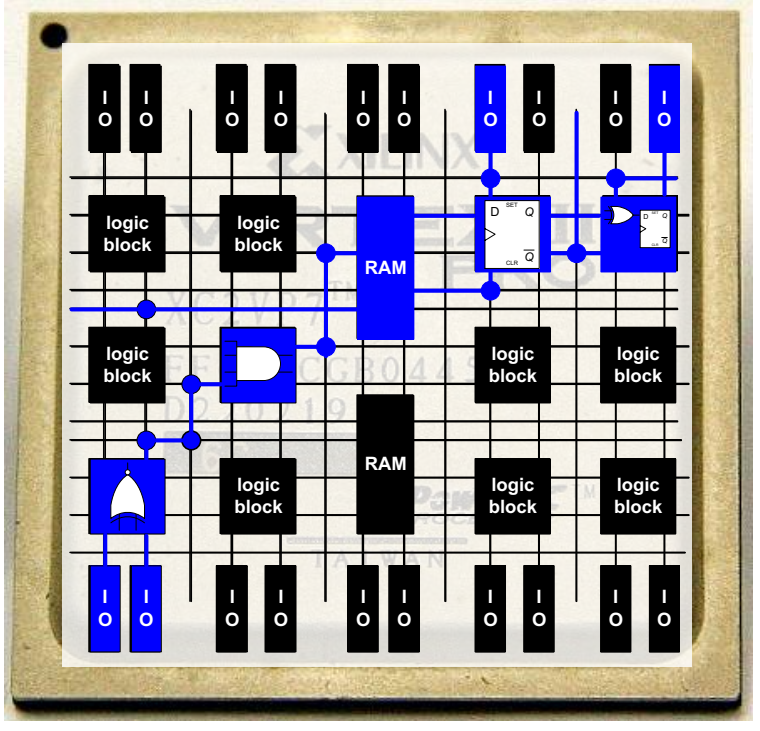
A brief introduction
to

Field Programmable Gate Arrays

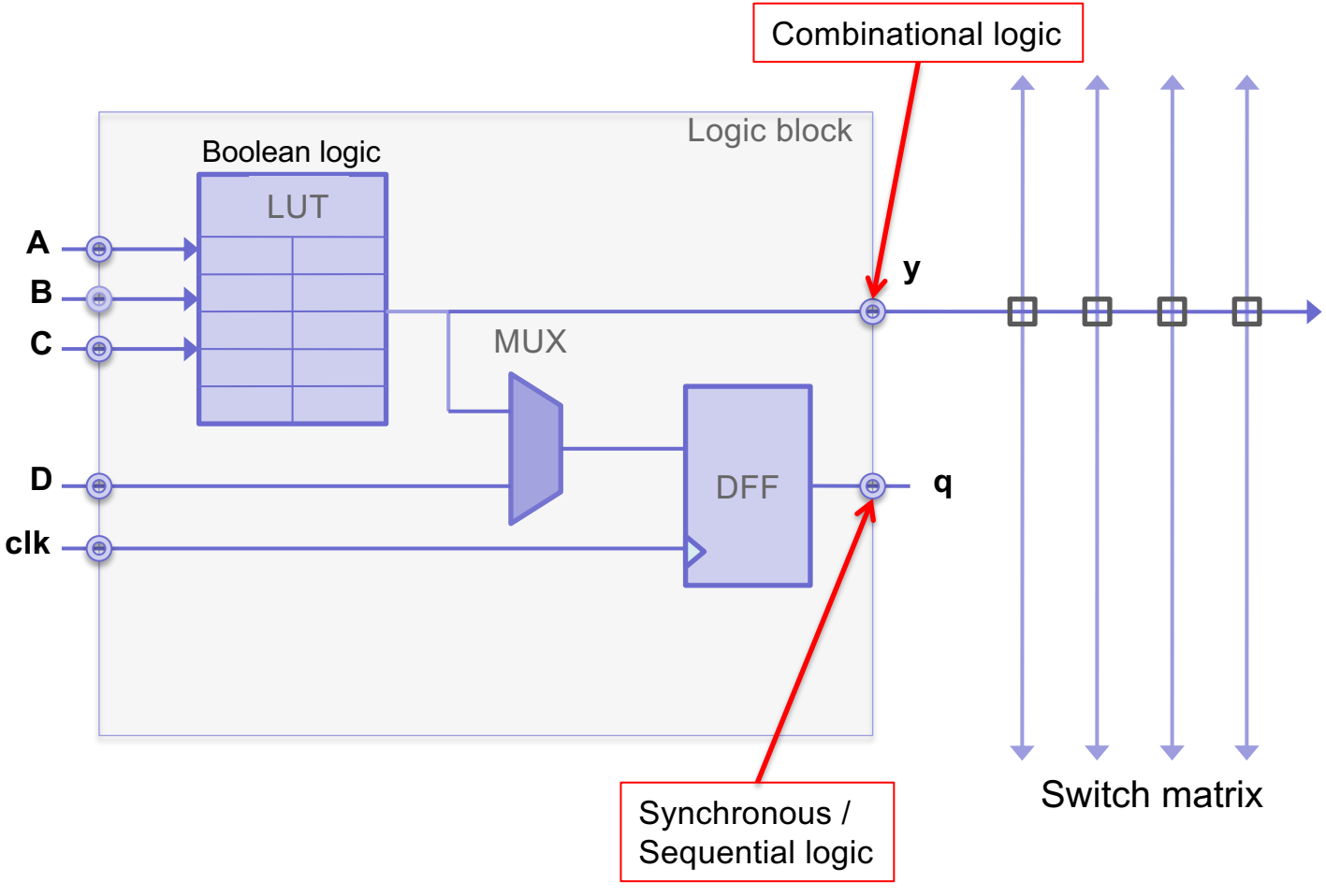
by
Ketil Røed

Field Programmable Gate Array

- Integrated circuit including a matrix of general-purpose programmable logic blocks.
- Functions described by a Hardware Description Language (VHDL, Verilog) and mapped into pre-existing programmable logic (Configuration)
- True parallelism (concurrency)

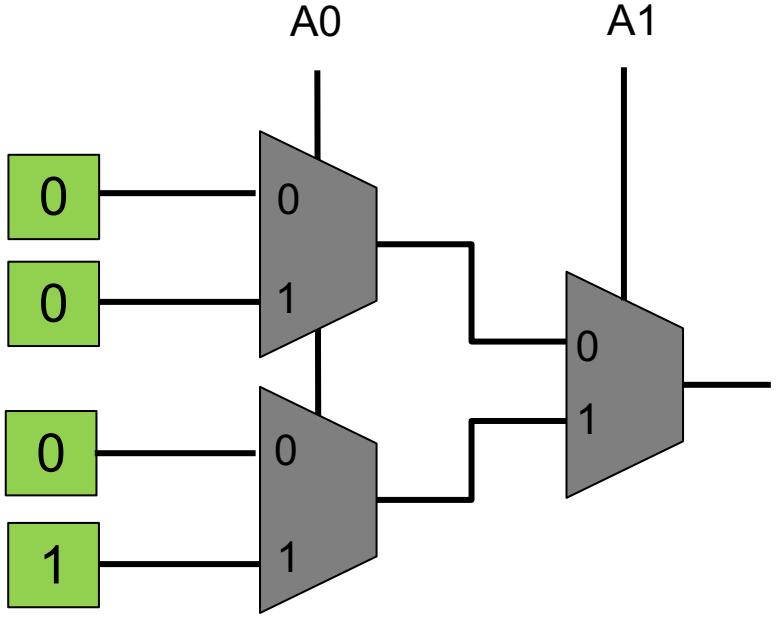


Programmable logic block



Look-Up Table (LUT)

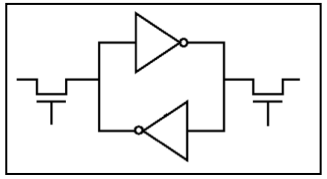
A1	A0	M
0	0	0
0	1	0
1	0	0
1	1	1



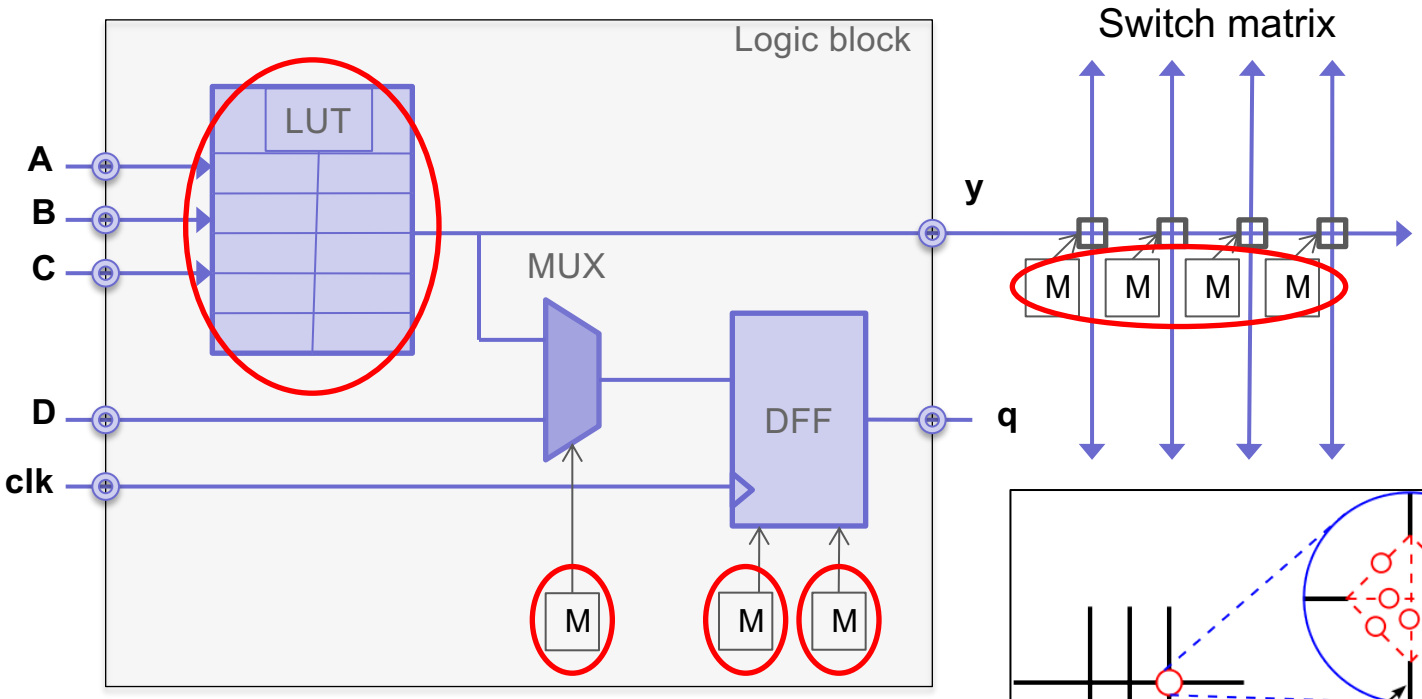
Two input AND-gate

Configuration bits

Configuration memory (LUT, M)
It defines the logic function and routing

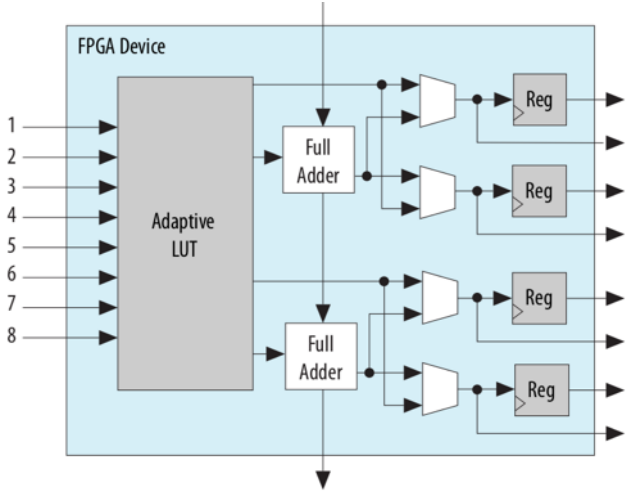


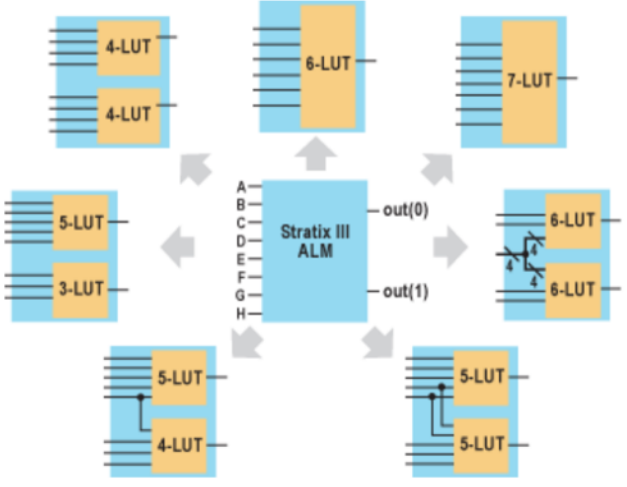
e.g. SRAM

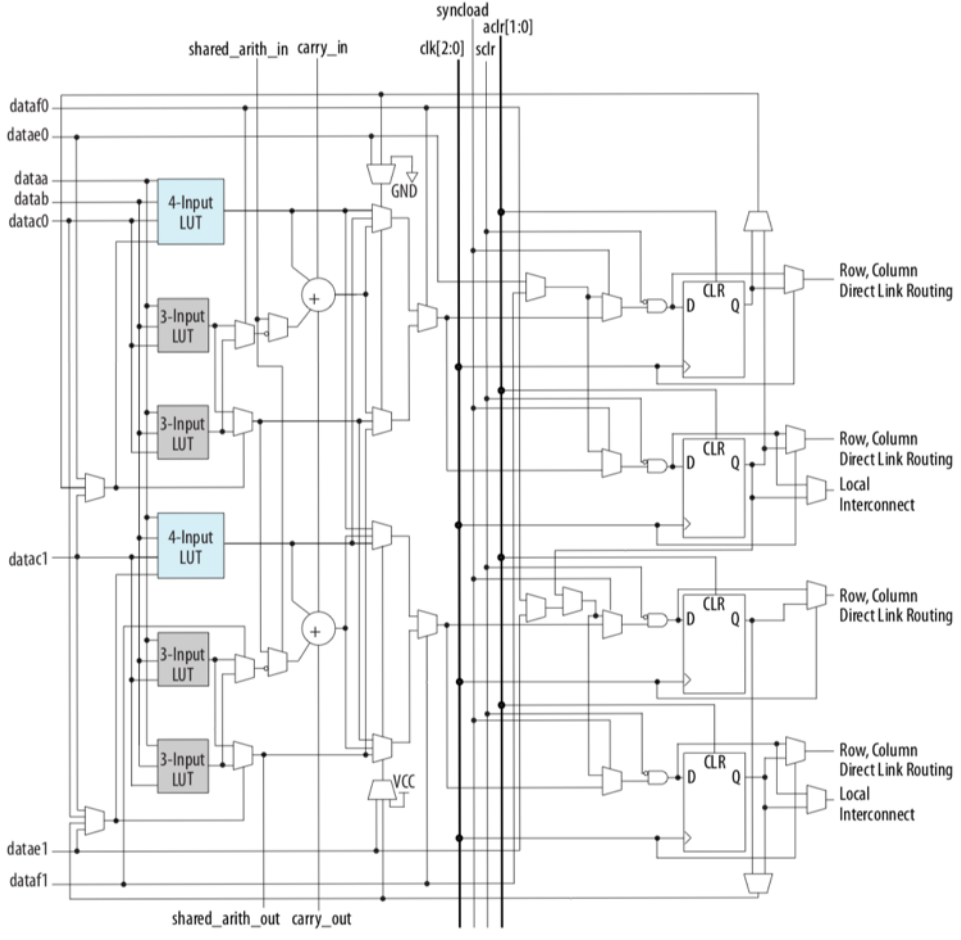


Additional FPGA resources (JTAG, POR, PLLs,etc)

Intel Adaptive Logic Module

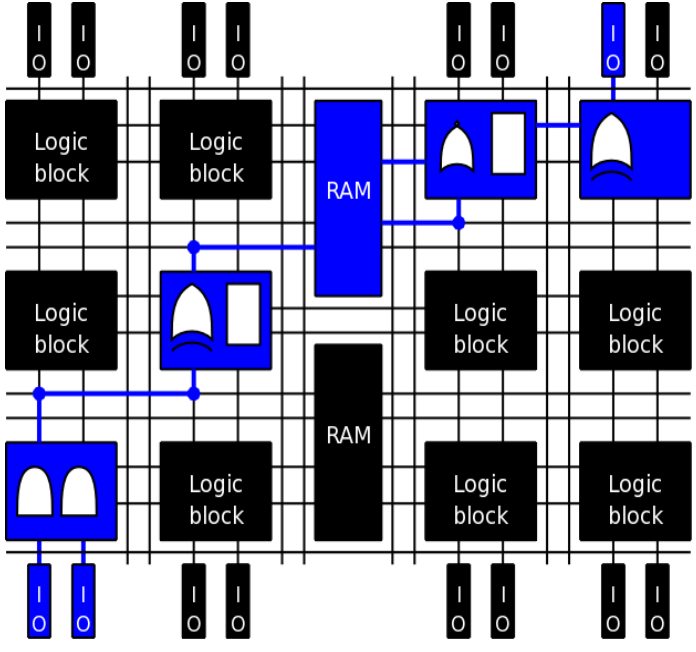






More info in Altera white paper “FPGA architecture”: https://www.altera.com/en_US/pdfs/literature/wp/wp-01003.pdf

From design to configuration



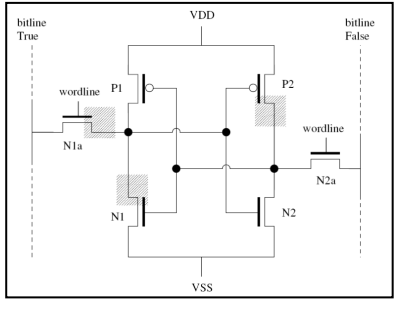

```
23 flipflop_proc: process(clk,areset_n)
24
25 begin
26     if (areset_n = '0') then
27         q <= '0' ;
28     elsif rising_edge(clk) then
29         q <= d ;
30     end if;
31 end process;
32
33 end behav;
34
```

Bit stream generated

Configure device

0101000101
0101011000
0101011110
1010010010

Bit value stored in Configuration memory cell

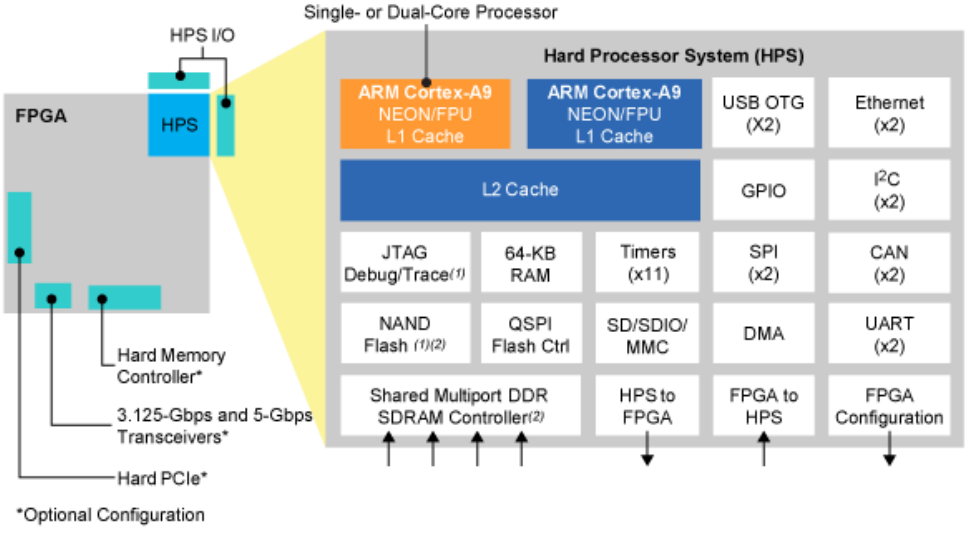


SRAM/
FLASH

High level synthesis (HLS)

- Automated process that interprets an algorithmic description of a desired behavior in a high-level development tool/language and creates digital hardware that implements that behavior.
  - C-code (development tool)
  - Matlab (HDL coder)
  - LabView (FPGA module)
- **Advantage:**
  - Easy to implement complex designs with e.g. mathematical operations and filters.
- **Disadvantage:**
  - Less control of the more complex HDL code.

FPGAs and Processors



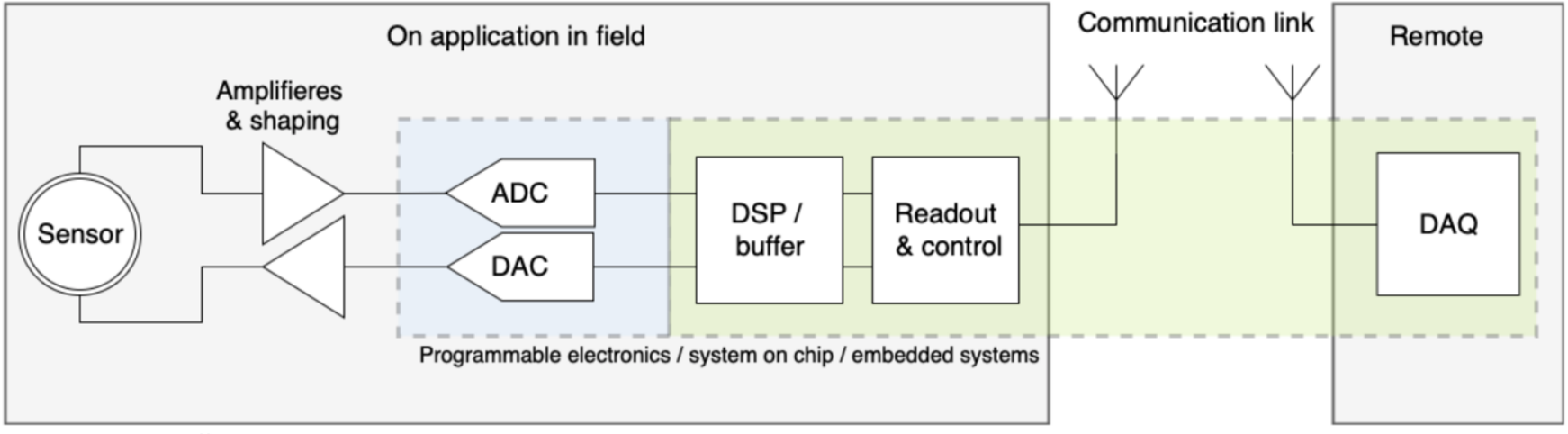
- Hard-core:
  - Modern FPGAs have Hard Processor Systems embedded in Silicon in addition to the programmable logic part.
- Soft-core:
  - Also possible to implement a CPU in HDL (soft-core)

Why FPGAs?

- Reconfigurable
- Short time to market (quick response to market demands)
- Excellent and low-cost choice for prototyping
- True parallelism with high I/O count
- High reliability, determinism & performance
- Can replace microcontrollers in designs with
  - A demand for high number & flexible I/O lines
  - A need for non-standard user interfaces
- Offers single chip solutions (SoC)

Icons by www.pngrepo.com

Application



Figur 2. Generell representasjon av et sensorsystem.

The answer is not always FPGAs

- Can be expensive compared to microcontrollers
- Often higher power consumption compared to microcontrollers
- High pin count => complex packaging (BGA)
- Complicated (i.e. clocking and timing)
- Complex tools
- HDL not necessarily easy or intuitive

- Often a microcontroller can do the job!

Main FPGA vendors

Summary

- Introduction to Field Programmable Gate Arrays
- Programmable logic block
- Look-up table
- Hardware Description language and how an FPGA can be configured
- Some advantages and disadvantages