

# Verilog

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# Verilog

- Verilog is a hardware description language (HDL).
- In this class, we use Verilog to implement and verify your processor.
- C/Java like syntax

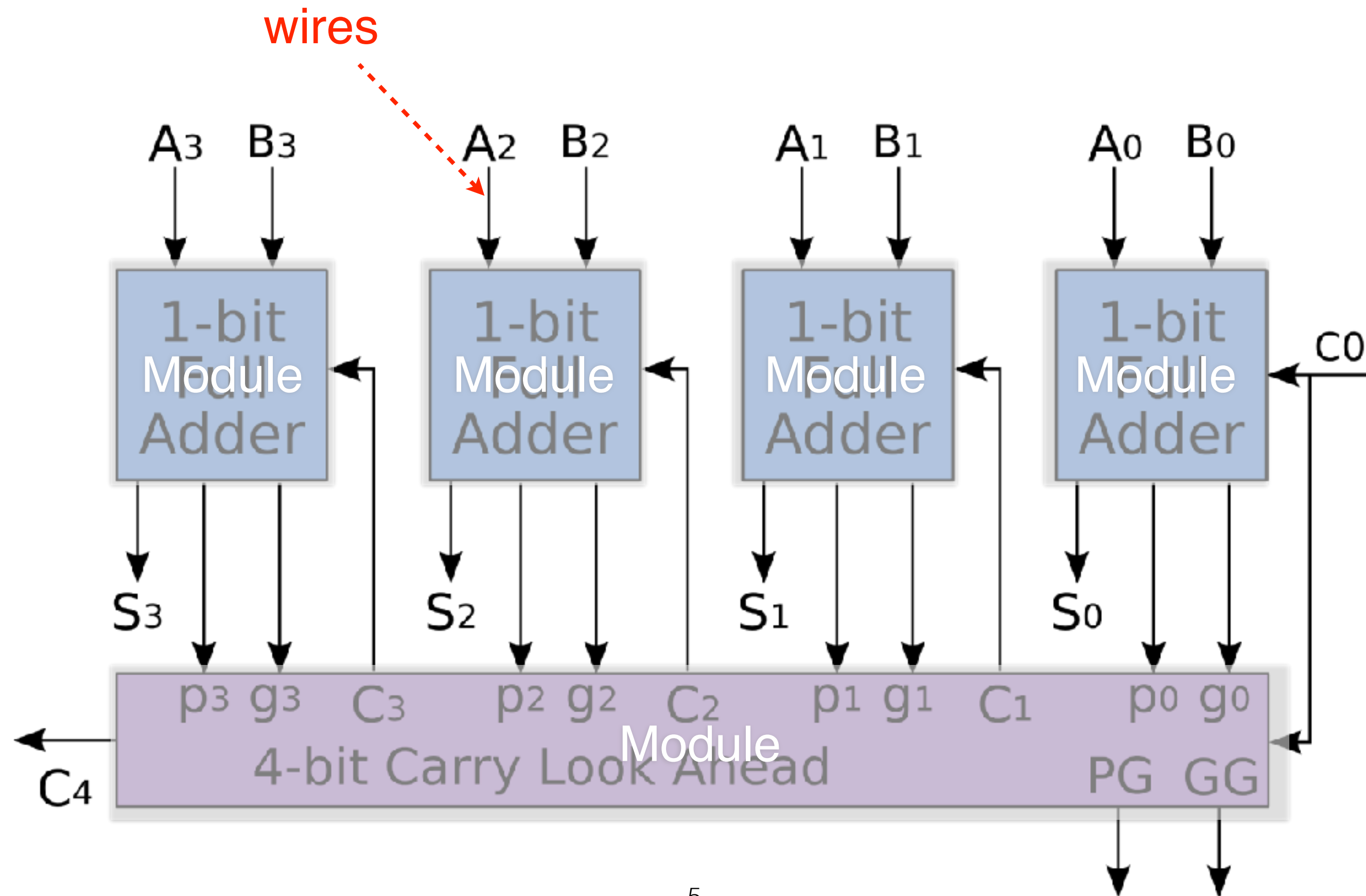
# Data type in Verilog

- Bit vector is the only data type in Verilog
- A bit can be one of the following
  - 0: logic zero
  - 1: logic one
  - X: unknown logic value, don't care
  - Z: high impedance, floating
- Bit vectors expressed in multiple ways
  - binary: 4'b11\_10 ( \_ is just for readability)
  - hex: 16'h034f
  - decimal: 32'd270

# Operators

- Arithmetic: + - \* / % \*\* (don't use the last three)
- Logic: ! && ||
- Relational: > < >= <=
- Equality: == != === !==
- Bitwise: ~ & | ^ ^~
- Reduction: & ~& | ~| ^ ^~
- Shift: >> << >>> <<<
- Concatenation: { }
- Conditional: ? :

# High-level view of hardware



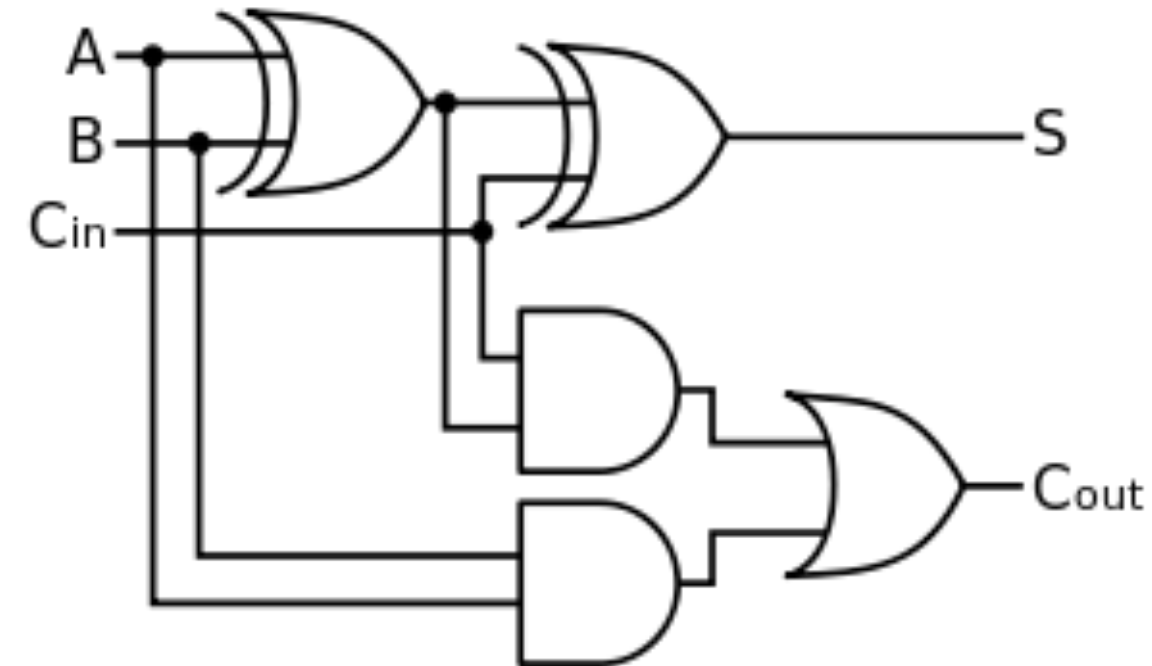
# Wire to connect things together!

- wire is used to denote a hardware net
  - single wire  
`wire my_wire;`
  - array of wires  
`wire[7:0] my_wire;`
- For procedural assignments, we will use reg
  - again, can either have a single reg or an array  
`reg[7:0] result; // 8-bit reg`
  - reg is not necessarily a hardware register
  - you may consider it as a variable in C

# Modules

- A Verilog module has a name and a port list
  - ports: must have a direction (input, output, inout) and a bitwidth
- Think about an 1-bit adder
  - input: 1-bit \* 3
  - output 1-bit \* 1 and 1-bit \* 1

```
module FA( input a,  
          input b,  
          input cin,  
          output cout,  
          output sum );  
assign sum = a^b^cin;  
assign cout = (a&b) | (a&cin) | (b&cin);  
endmodule
```



# Always block

- Executes when the condition in the sensitivity list occurs

```
always@(posedge clk)
begin
...
...
end
```

```
module FA( input a,
           input b,
           input cin,
           output cout,
           output sum );

    reg s, cout

    always@(a or b or cin)
    begin
        sum = a^b^cin;
        cout = (a&b) | (a&cin) | (b&cin);
    end
endmodule
```



# Blocking and non-blocking

- Inside an always block, = is a blocking assignment
  - assignment happens immediately and affect the subsequent statements in the always block
- <= is a non-blocking assignment
  - All the assignments happens at the end of the block

Initially, a = 2, b = 3

```
reg a[3:0];
reg b[3:0];
reg c[3:0];
always @(posedge clock)
begin
a <= b;
c <= a;
and
Afterwards: a = 3 and c = 2
```

sequential logic

```
reg a[3:0];
reg b[3:0];
reg c[3:0];
always @(*)
begin
a = b;
c = a;
and
Afterwards: a = 3 and c = 3
```

combinational logic

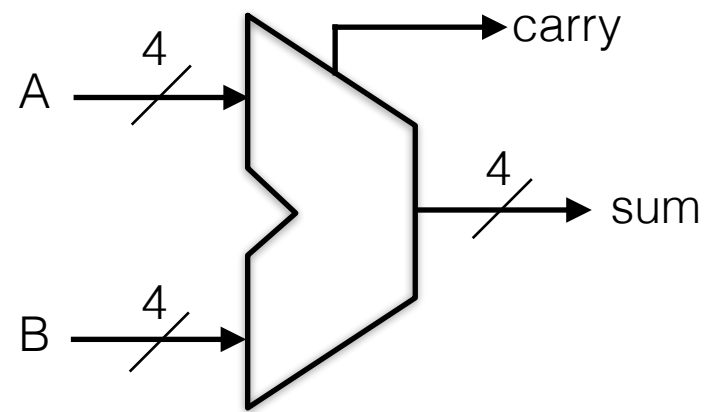
# Initial block

- Executes only once in beginning of the code

```
initial  
begin  
...  
...  
end
```

# Modules

- A verilog module can instantiate other modules



```
module adder(input [3:0] A,  
            input [3:0] B,  
            output carry,  
            output [3:0] sum);  
  
    wire c0, c1, c2  
    FA fa0(A[0],B[0],cin,c0,sum[0]); // implicit binding  
    FA fa1(.a(A[1]), .b(B[1]), .cin(c0), .sum(sum[1]), .cout(c1));  
    // explicit binding  
    FA fa2(A[2],B[2],c1,c2,sum[2]);  
    FA fa3(A[3],B[3],c2,cout,sum[3]);  
endmodule
```

# Testing modules

```
`timescale 1ns/1ns // Add this to the top of your file to set time scale
module testbench();
reg [3:0] A, B;
reg C0;
wire [3:0] S;
wire C4;
adder uut (.B(B), .A(A), .sum(S), .cout(C4)); // instantiate adder

initial
begin
A = 4'd0; B = 4'd0; C0 = 1'b0;
#50 A = 4'd3; B = 4'd4; // wait 50 ns before next assignment
#50 A = 4'b0001; B = 4'b0010; // don't use #n outside of testbenches
end

endmodule
```

# Resources

- Check out MIT's 6.375 course webpage  
<http://csg.csail.mit.edu/6.375/>
  - thanks to Asanovic & Arvind for slides
- Tips for using Altera tools  
<https://sites.google.com/a/eng.ucsd.edu/using-the-altera-tools/>
  - Thanks to Steven Swanson and other CSE141L winter 2012 staffs

# Q & A