

Introduction to Verilog

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(Modified from Winter 11 slides by Omid Ardakanian)

CS 450/650 - Computer Architecture

University of Waterloo

Outline

- Introduction
- CAD tools for Verilog
- How to write “Hello World!” in Verilog
 - Module Declaration
 - Register vs. Wire
 - Vectors vs. Arrays
 - Data Types
 - Primitives
 - Port Connection Rule
- Assignment

Introduction (What are HDLs?)

- Definition...
- Popular HDLs
 - Verilog (Verifying Logic)
 - VHDL
- Why are HDLs essential?

Verilog vs. VHDL

- VHDL
 - More general language
 - Not all constructs are synthesizable
- Verilog
 - Not as general as VHDL
 - but easier to learn than VHDL
 - Most constructs are synthesizable
 - Its syntax is similar to C

CAD tools for Verilog

- Why do we need a CAD tool?
 - Fast design
 - Debugging and testing (*simulation*)
 - It is necessary for *synthesis*
- Popular examples:
 - Modelsim
 - Verilog-XL
 - VCS
 - Icarus Verilog

One-bit Full Adder (full_adder)

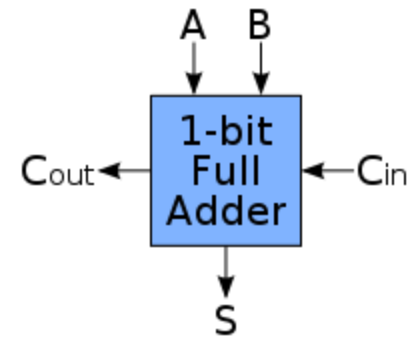
module name

port declaration (input, output, inout)

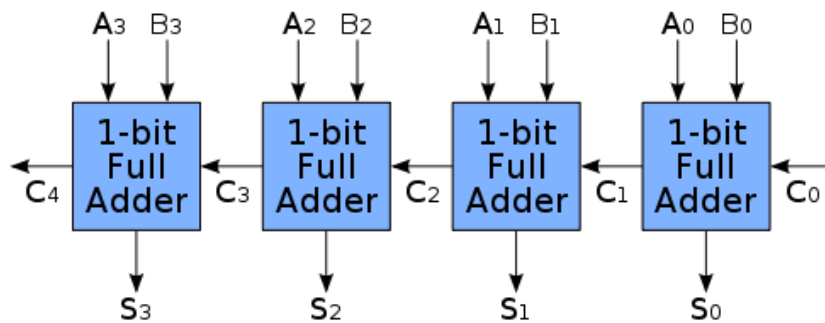
```
module full_adder(a,b,cin,sum,cout);  
    input a, b, cin;  
    output sum, cout;  
  
    assign sum = cin ^ a ^ b;  
    assign cout = ~cin & a & b | cin & (a | b);  
endmodule
```

port list

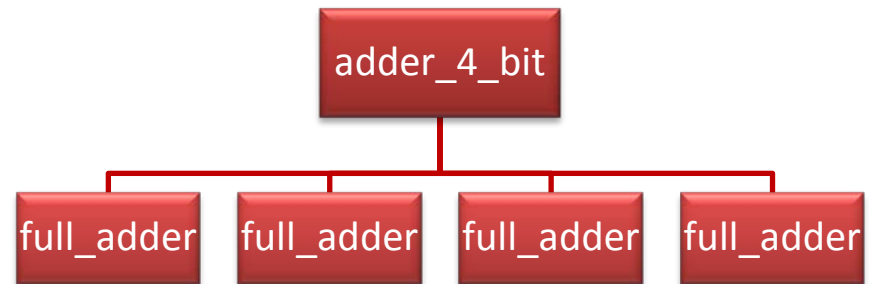
module internals



4-bit Ripple Carry Adder



Schematic Design of a 4-bit
Ripple Carry Adder



Design Hierarchy

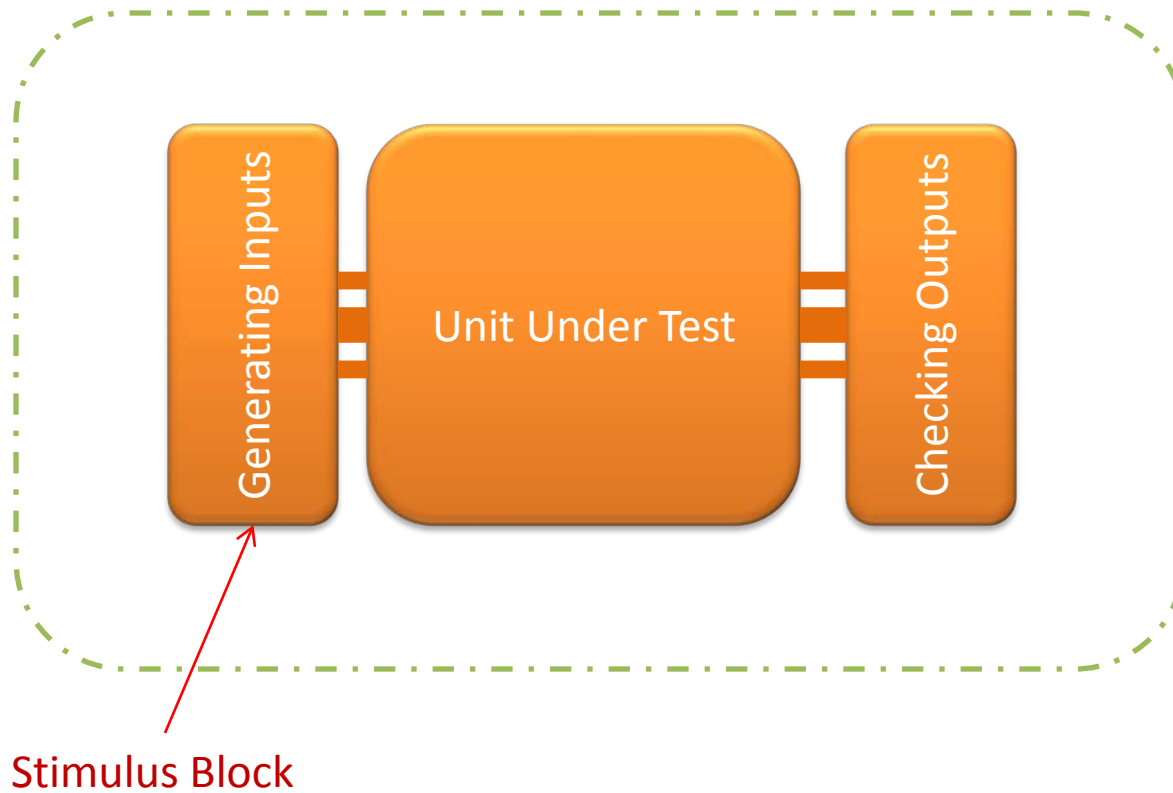
4-bit Ripple Carry Adder (adder_4_bit)

```
module adder_4_bit(x,y,cin,z,cout);  
    input [3:0] x ,y;  
    input cin;  
    output [3:0] z;  
    output cout;  
    wire [3:1] carry;  
  
    full_adder fa0(x[0],y[0],cin,z[0],carry[1]);  
    full_adder fa1(x[1],y[1],carry[1],z[1],carry[2]);  
    full_adder fa2(x[2],y[2],carry[2],z[2],carry[3]);  
    full_adder fa3(x[3],y[3],carry[3],z[3],cout);  
endmodule
```

instance
name



Test Bench



Test Bench (adder_4_bit_tb)

```
module adder_4_bit_tb;
    reg [3:0] x, y;
    reg cin;
    wire [3:0] z;
    wire cout;

    adder_4_bit a0(x,y,cin,z,cout);

    initial begin
        x = 0; y = 0; cin = 0;
        #10 x = 4'b0101; y = 4'b0001; cin = 1'b0;
        #10 x = 4'b0101; y = 4'b1110; cin = 1'b1;
        #10 x = 0; y = 0; cin = 0;
        #10 $finish;
    end
endmodule
```

timing



Putting All Together

```
% iverilog -o FullAdder full_adder.vl adder_4_bit.vl  
    adder_4_bit_tb.vl
```

```
% vvp FullAdder
```

```
%
```

Test Bench (...again)

```
module adder_4_bit_tb;  
    ...  
    initial begin  
        $dumpfile("fullAdder.vcd");  
        $dumpvars(0, adder_4_bit_tb);  
  
        $monitor(x, ,y, ,cin, ,z, ,cout);  
        ...  
    end  
endmodule
```

Putting All Together

```
% iverilog -o FullAdder full_adder.vl adder_4_bit.vl  
    adder_4_bit_tb.vl
```

```
% vvp fullAdder
```

```
VCD info: dumpfile fullAdder.vcd opened for output.
```

```
0  0 0  0 0
```

```
5  1 0  6 0
```

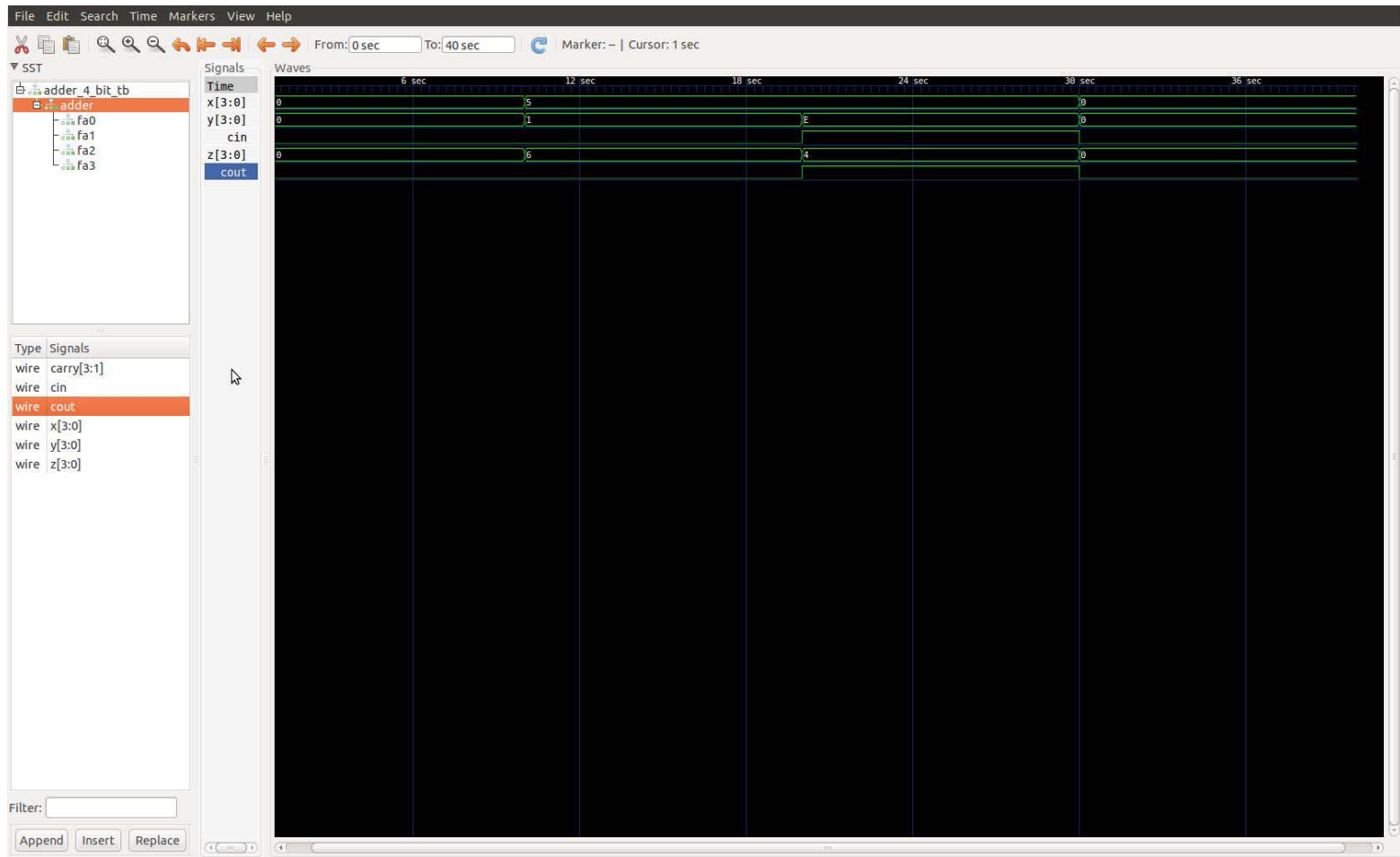
```
5 14 1  4 1
```

```
0  0 0  0 0
```

```
%
```

```
%gtkwave fullAdder.vcd
```

Waveform



VCD file opened with *GTKWave*

Register vs. Wire

- wire
 - Represents connection between components
 - Its value is determined by the value of its drivers
 - Its default value is z
- reg
 - Retains its value until next assignment
 - Its default value is x

Vectors vs. Arrays

- Vectors
 - To define multiple width wires or registers
 - Definition:
 - `wire/reg [msb_index : lsb_index] data_id;`
- Arrays
 - It is possible to have reg, integer and time arrays
 - Definition:
 - `<data_type> <var_name>[start_idx : end_idx];`

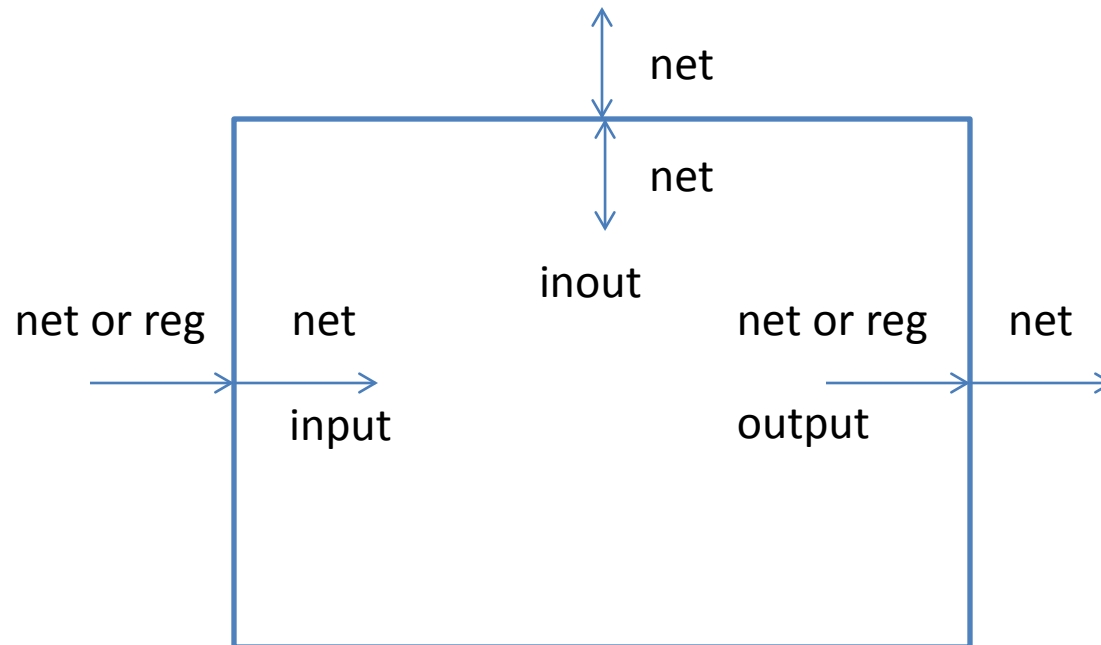
Data Types in Verilog

- Net
- Register
- Integer
- Real
- Time
- ...

Primitives

- and/nand
 - or/nor
 - xor/xnor
 - buf/not
-
- Example: and a1(out, in1, in2)

Port Connection Rules



Assignment

- Install Icarus
- Write a 4-bit adder with Carry Look Ahead
- Write a test bench for it
- See the wave form of the output

Some Resources

- Verilog Tutorial Website

<http://www.electrosofts.com/verilog/>

- Icarus Verilog wiki

<http://iverilog.wikia.com/wiki/GTKWAVE>

- Links and the slides will be posted in the course homepage

<http://www.student.cs.uwaterloo.ca/~cs450>