CAST Circuit Description Language

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What is CAST?

- A Hardware description language
  - Not to be confused with a programming language!
- Describe logic circuits at the gate level
  - Build up from primitives (Nand, Nor, Inverter)
- Define circuit blocks
- Simulate the functionality of circuits
  - Show signals as (bundled) waveforms

Data Types

- We give you three logic “blocks” with the following interfaces
  - Nand2()(a,b,out)
  - Nor2()(a,b,out)
  - Inv()(a,_a)
  - You can find the definitions of these blocks in **`/usr/local/cad/cast/314/parts.cast`**
- Primitive type is a node
  - Think of this as a wire in a logic circuit

Defining Functional Blocks

- Lets take a look the definition of Nand2() in parts.cast…

```
define Nand2()(node a,b; node out){
  prs{
     ~a | ~b -> out+
      a & b  -> out-
  }
}
```

Function Headers

- The header of a block has a standard format
  - define *BlockName*([*parameter list*])(*inputs*;*outputs*)
  - The parameters are useful for generalizing gates, more on this later
  - Inputs and output lists follow the convention that a type is followed by a comma separated list of node names, and types are separated by semicolons
- Header defines the *interface* of your block

Function Body

- You should not have to write a body that looks anything like the body of Nand2().
- Function bodies that you write will only *instantiate* other blocks (yours or the primitive ones we give you) and *wire* the gates by specifying which nodes are connected

Instantiation

- Blocks can be instantiated and wired in several ways
  - `node a,b,c;Nand2 g1;g1.a=a;g1.b=b;g1.out=c;`
  - `node a,b,c; Nand2()(a,b,c);` (anonymous gate)
  - `node a,b,c; Nand2() g1(a,b);` (named gate)
- Note the equal sign means *connection* not assignment – remember it's not programming, its circuit description…
  - What you are really doing is aliasing the names

A Simple Example

- Want an AND gate… draw a picture… then *describe it* with CAST

```
define And2()(node a,b; node out){
  Nand2() g1(a,b);
  Inv()(g1.out,out);
}
```

Arrays

- CAST also allows you to declare an indexed array of nodes as follows
  - `node[10] b; //declares b[0]..b[9]`
- You can also make arrays of blocks you define
  - `And2[10] b; //declares 10 AND gates`
- Nice feature because most logically constructed circuits exploit repetition

Ranges

- CAST supports the ability to pick the index range when you declare an array as well
  - node[6..10] x; //declares nodes x[6]..x[10];
- You can also specify a subset of an array using similar notation (useful for connection)

Connecting Arrays

- Arrays can be connected to one another using the "=" operator
  - Only restriction is the arrays (or ranges) being connected must be the same size (obviously)
  - The following syntax connects x[3] to y[8], x[4] to y[9], and x[5] to y[10].
  - x[3..5] = y[8..10];

Loops and Conditionals

- CAST provides *syntactic constructs* to make the wiring more “elegant”
  - !!Caution!! This is not a way of specifying circuit behavior… its just a way of being concise in your *description* of the circuit!
- Loops have the following structure
  - <i:*range*: (*some CAST statements*) >
- Conditionals have the following structure
  - [*condition* -> (*some CAST statements*)]

Parameterized Types

- Sometimes you may want to make a block more general
  - Instead of making a 3-bit adder, a 4-bit adder, etc., you could make one adder definition and parameterize it by how many bits you'd like it to be.

```
define adder(int N)(node[N] a,b,sum; node cout)
```

- Can use parameters in things like loop bounds, conditionals and such… exploit circuit *structure*

Parameterized Example

- Bitwise AND of two N-bit variables…
  - This is easy, just N AND gates, right?

```
define BitAnd(int N)(node[N] a,b; node[N] out){
  <i:N: And2()(a[i],b[i],out[i]);>
}
```

- Isn't that pretty ☺

Miscellaneous Tips

- Don't start coding CAST until you've drawn yourself a circuit diagram
- CAST also allows you to define your circuit recursively… this is actually *really* useful for generalizing certain circuit topologies like trees
  - Important from an efficiency standpoint!
- You should have a file called myparts.cast that you include in each cast definition file you make
  - Myparts.cast should have as its first line
  - **`import "314/parts.cast";`**

Simulating

- Once you have your definitions all set you ***must*** instantiate the definition you want to test
- You can then run the following command on the file which contains your instantiation

  `prs2sim` ***`filename`*** **`.cast`**

- This creates two new files:
  - ***`filename`*** **`.sim`** and ***`filename`*** **`.al`**

Simulating

- You are now ready to simulate your circuit by typing the following!
  - **`irsim.sh`** ***`filename`*****`.sim`** ***`filename`*****`.al`**
  - You can type help to see a list of all available commands irsim offers, and help *command* to get help on a specific command

Simulation

- The basic thing you do in IRSIM is set input nodes high or low, take a step forward in time, and observe the changes (if any) in the output nodes
  - To set node A high you say: h A <enter>
  - To set node A low you say: l A <enter>
  - To take a step you say: s <enter>
  - Usually don't simulate "interactively"…

IRSIM Command Files

- Instead you can type your simulation into a separate file and then just type the filename in after launching irsim to run your script…
- Lets say I defined some function FOO that takes inputs: node[8] a,b; and produces outputs node[3] c;

IRSIM Command Files

- A typical command file might look like this:

```
vector A a[{7:0}]
vector B b[{7:0}]
vector C c[{2:0}]
ana -b A B C |graphical analyzer, show vectors in binary
set A 01001011 |set the value using a binary number
set B %xf4 |set the value using a hex number
s  |take a step (you can set duration with stepsize)
set A %x11
s
...
```