Design Hierarchy And VLSI Design Flow

Dr Noor Mahammad Sk

Hprcse

Evolution of CAD Tools

- Digital circuit design evolved over last three decades
- SSI – Small Scale Integration (Tens of transistors)
- MSI – Medium Scale Integration (Hundreds of transistors)
- LSI – Large Scale Integration – (Thousands of Transistors) - demanded automation of design process – CAD started evolving.

Evolution of CAD Tools

- VLSI – Very Large Scale Integration – Tens of Thousands of Transistors – CAD Tools are inevitable
- VLSI chip design forced
  - Automation of process
  - Automation of Simulation based verification - replacing breadboard techniques – HDL development
  - Modular and Hierarchical techniques of design – a natural object orientation approach

CAD Terminologies

- HDL – Hardware Description Language
  - Describing a circuit to the computer
  - A programming language by all means
  - Concurrency constructs to simulate circuit behavior
  - Verilog and VHDL
  - Simulation for verification and Synthesis
  - Synthesizable constructs - RTL

CAD Terminologies

- RTL – Register Transfer Level
  - Specifying how the data flows between registers and how the design processes data
  - Registers store intermediate results
  - Logic between any two registers in a data flow determines the speed of the circuit
- Synthesis – Converting RTL to a set of gates and wires connecting them – Ambit of Cadence, Design Compiler of Synopsys, *Precision* of Mentor, Blast Fusion from Magma are some of the commercially available synthesis tools.

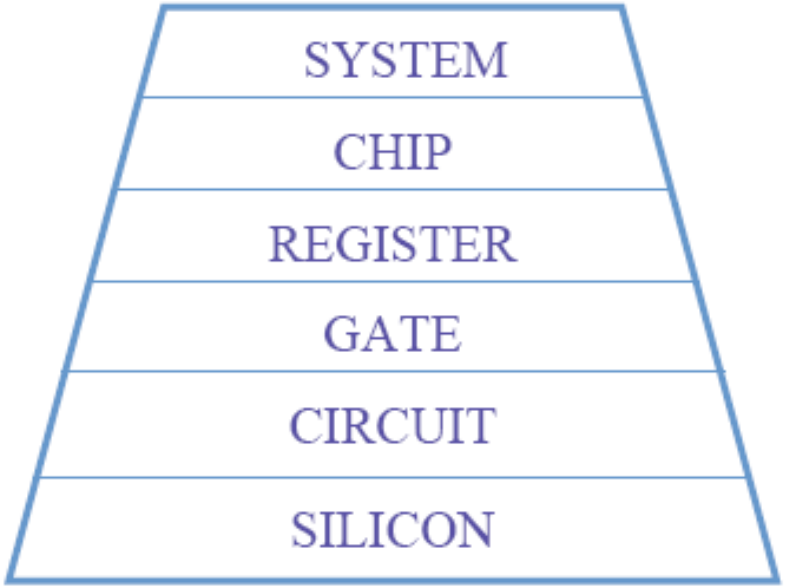
Design Flow

- The process of converting an “idea”to a “chip”is called the VLSI Design Process.
- VLSI Design Process involves a sequence of steps –Flow.
- Tools that enable the design process are called CAD (Computer Aided Design) tools for VLSI.

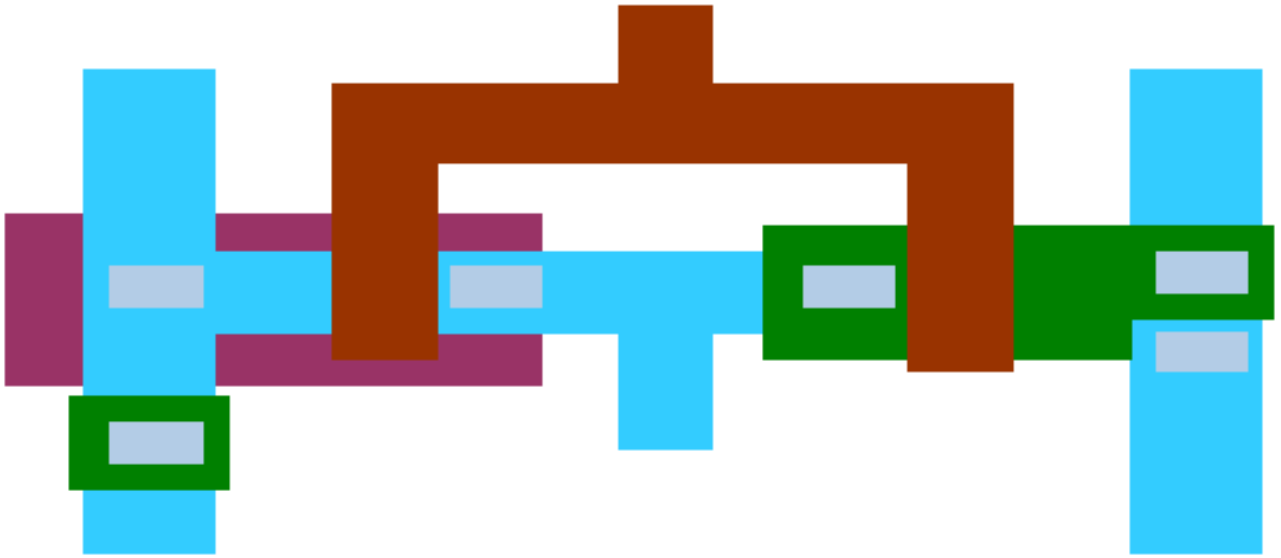
Abstraction Hierarchy

- Designers use different abstraction domains for VLSI design.
- Structural Domain
  - Set of primitive components.
  - Primitive components are interconnected to form larger components.
- Behavioral Domain
  - Components are defined by their input/output response.
  - The components can themselves be implemented in many ways.

Abstraction Levels

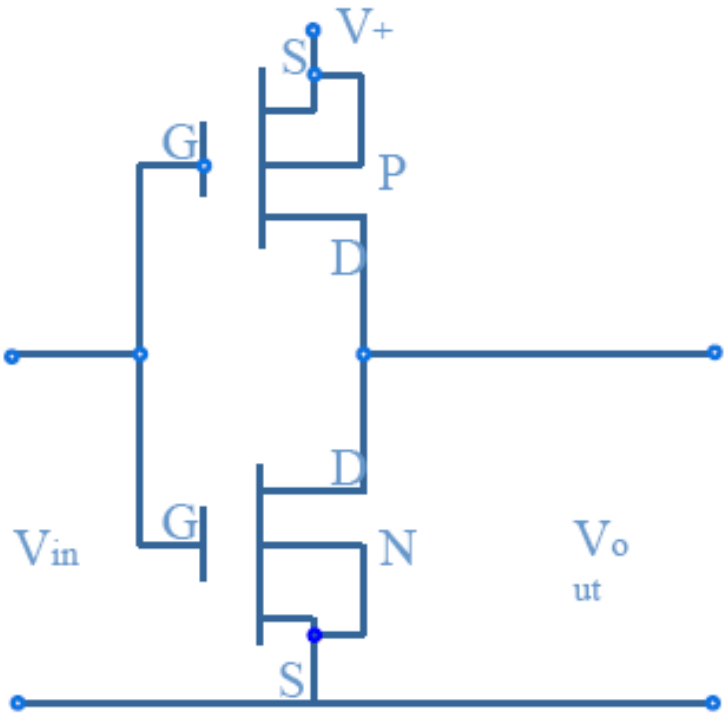


Silicon Level



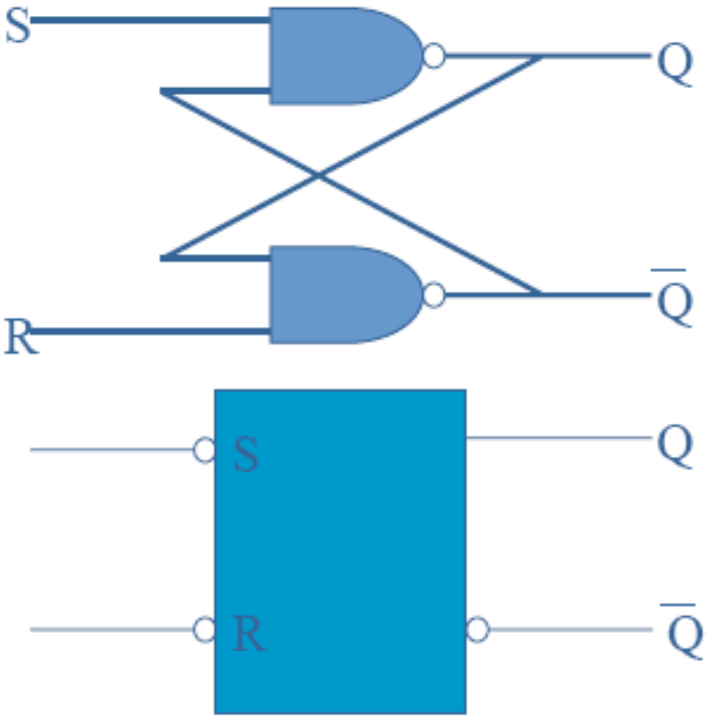
Circuit Level

Inverter

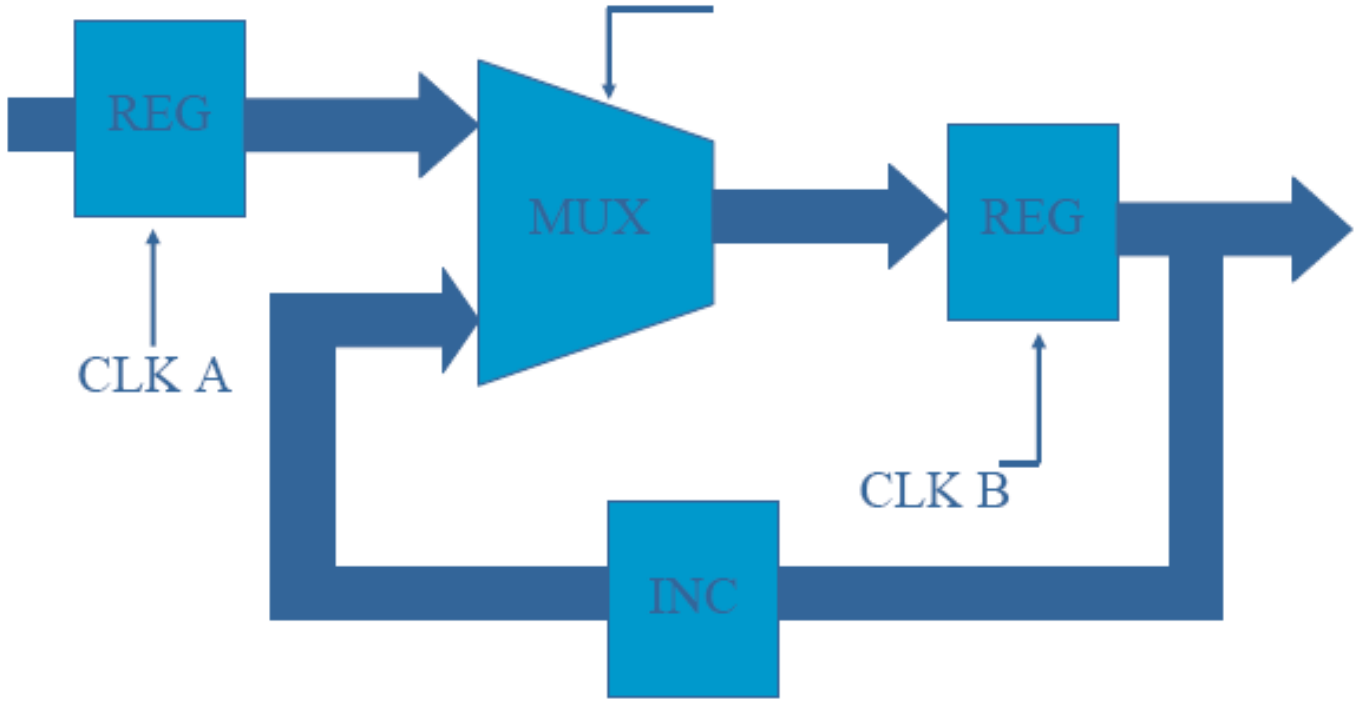


Gate Level

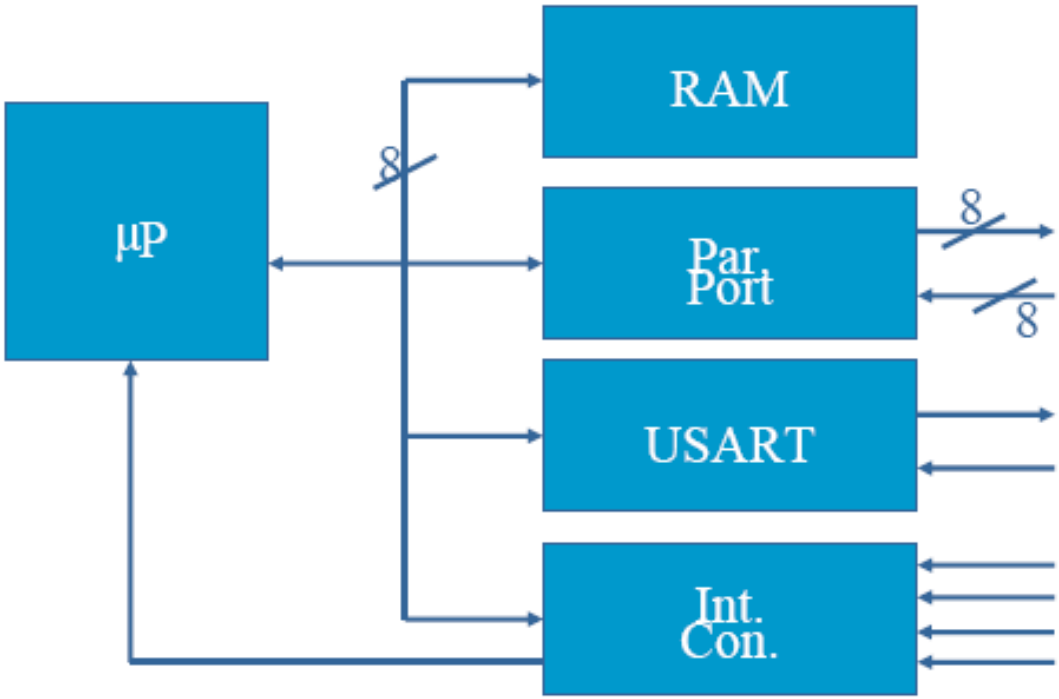
SR Flip Flop



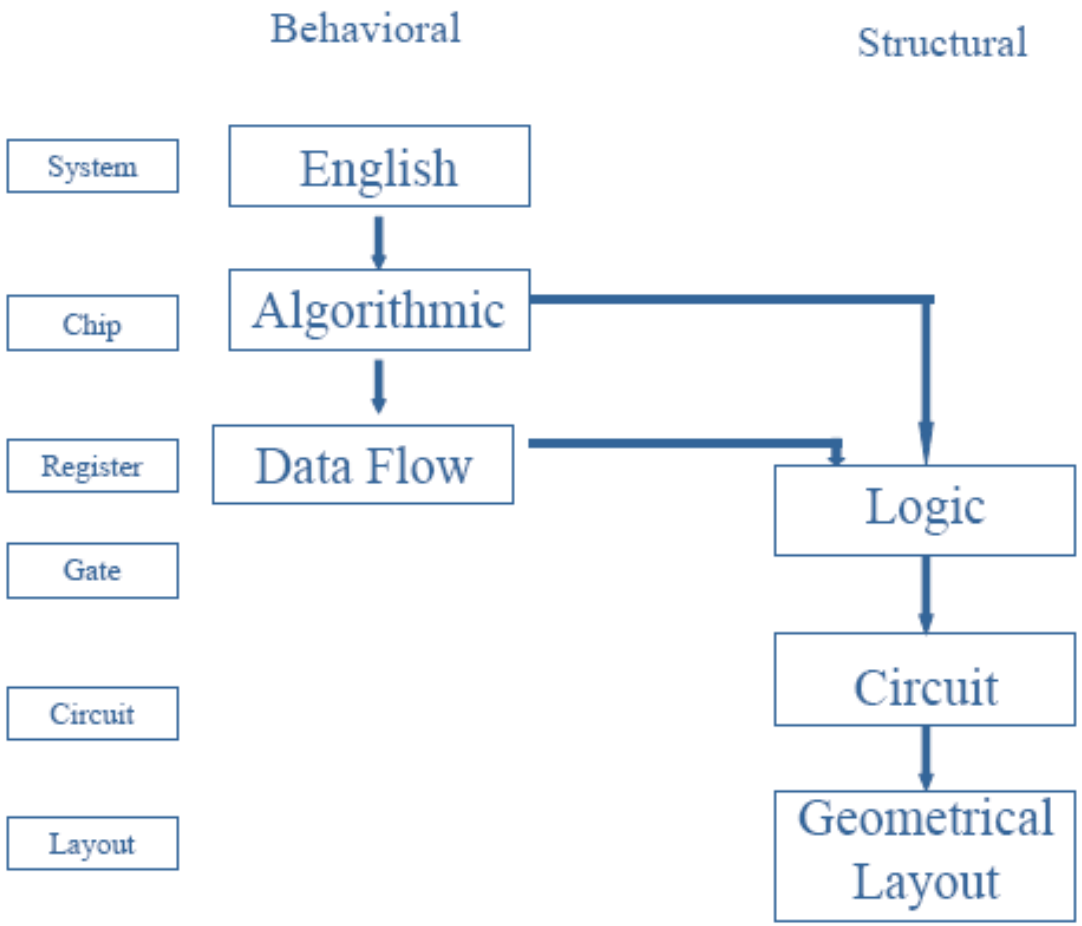
Register Level



Chip Level



Typical Design Track

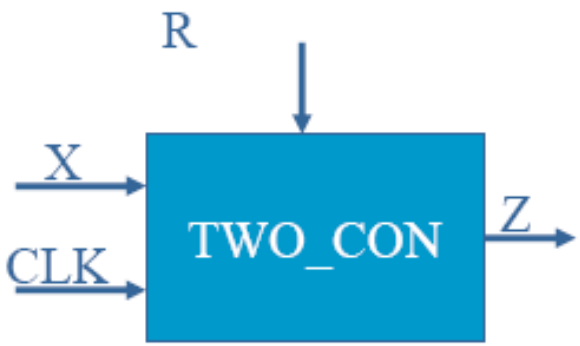


Design Representation

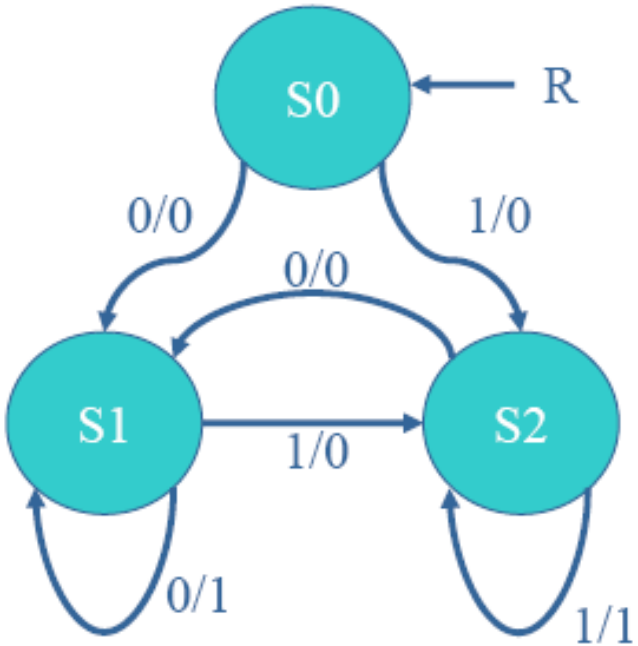
- Done in many ways
- Pictures
- Text
- *Is picture worth a thousand words?*

Design Representation Using Pictures

Specification: Detect inputs that are identical and in sequence



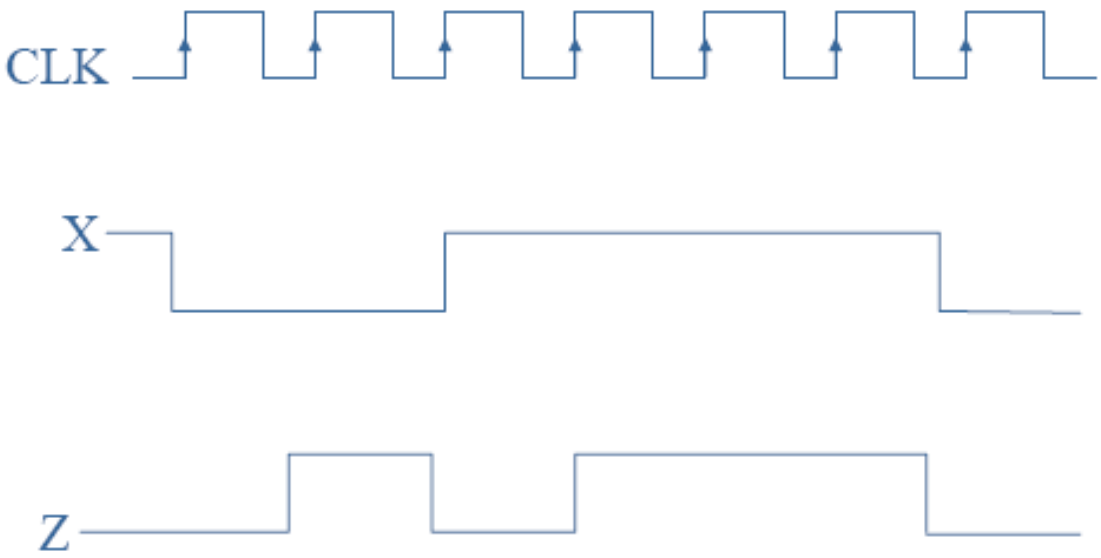
Block diagram



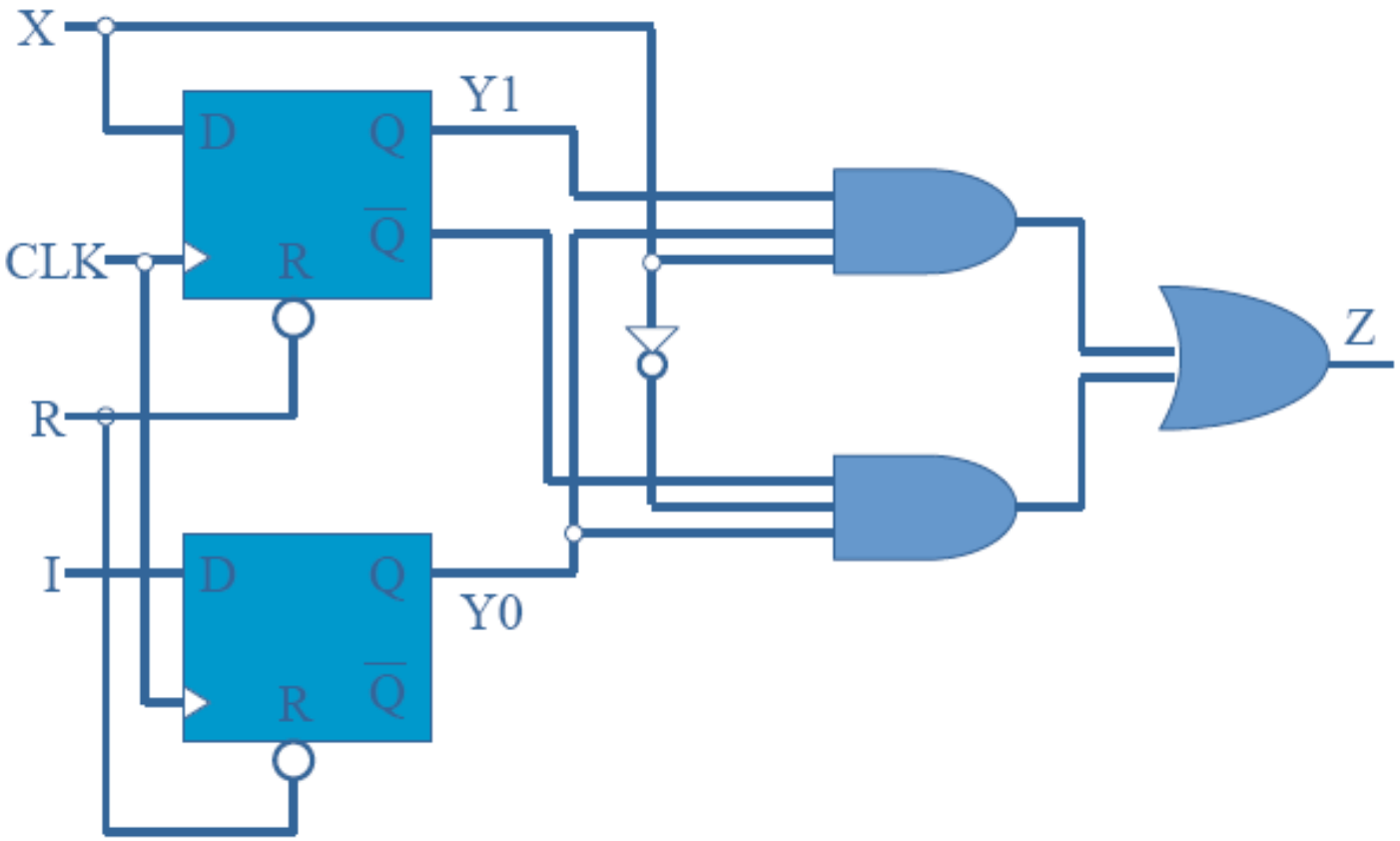
State diagram

Hprcse

As a Timing Diagram



As a Circuit

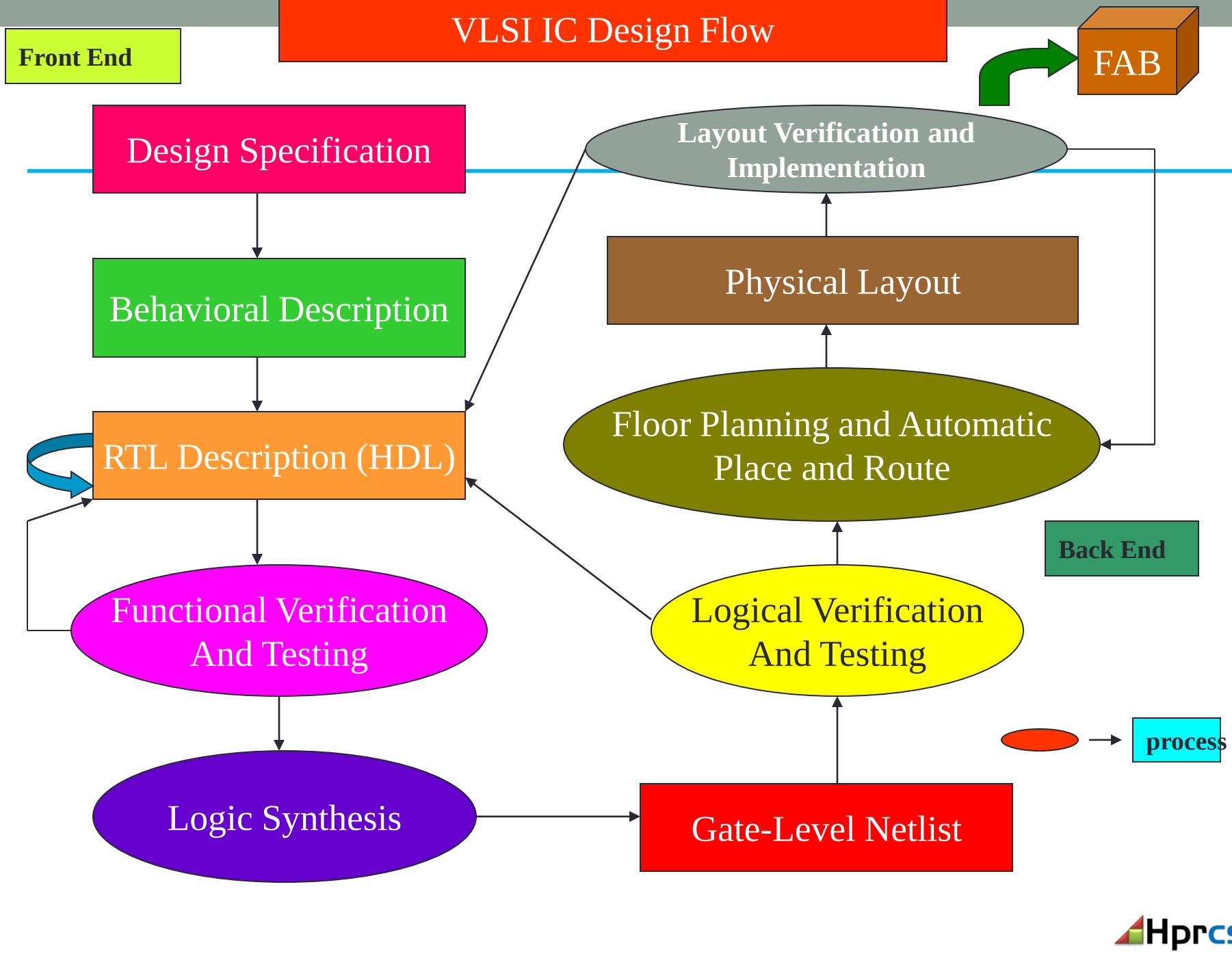


And in Verilog

```
module detector (Xin, clk, R, I, Zout);
input Xin, clk, R, I;
output Zout;
reg Y1, Y0;
   initial
   begin
            Y1 = 1'b0; Y0 = 1'b0;
   end
   always@(posedge clk or negedge R) begin
            if (R== 1'b0) begin
                     Y1 = 1'b0; Y0 = 1'b0;
            end
            else begin
                     Y1 = Xin; Y0 = I;
            end
   end

assign Zout =  Y0 & ((!Y1 & !Xin) | (Y1 & Xin));
endmodule
```

VLSI IC Design Flow



Hprcse

HDL

- HDL stands for **Hardware Description Language**
- Definition : A high level programming language used to model hardware.
- Hardware Description Languages
  - have special hardware related constructs.
  - currently model digital systems, and in future can model analog systems also.
  - can be used to build models for simulation, synthesis and test.
  - have been extended to the system design level.

Why Use HDLs

- Allows textual representation of a design.
- High level language similar to C,C++.
- Can be used for Modeling at the
  - Gate Level
  - Register Level
  - Chip Level
- Can be used for many applications at the
  - Systems Level
  - Circuit Level
  - Switch Level
- Design decomposition is simple with HDLs and hence can manage complexity
- Early validation of designs.

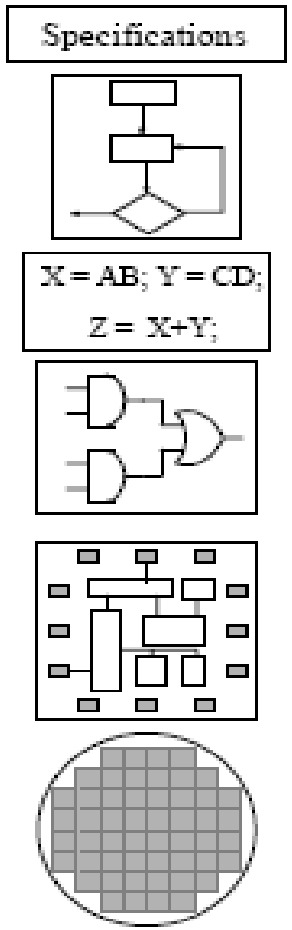
Need for Design Tools

- Current systems are very complex.
- Design abstraction and decomposition is done to manage complexity.
- Tools automate the process of converting your design from one abstraction level to another.
- Design Automation Tools improve productivity.
- Different tools are required in different steps.

Classification of CAD Tools

- Editors
  - Allows specification of the design either textually or graphically.
- Simulators
  - Models the response of a system to input stimuli.
- Analyzers
  - Used at different levels to check for correctness and compliance to rules.
- Synthesis
  - Transformation of representation between different abstraction levels.

Flow and Tools



Specifications

↓

Functional Design

↓

Logic Design

↓

Circuit Design

↓

Physical Design

↓

Fabrication

← System Description Languages

← Hardware Description Languages, Schematic Editors

← Logic Synthesis Tools (Tech mappers)

← Physical Synthesis Tools (Place & Route)

← Tape out and Manufacture

Hprcse

CAD Tools -1 Design entry

- Graphical
  - Silicon Level – To create layouts
    - e.g. Magic
- Other Levels
  - e.g. ViewLogic, Protel
- Text
  - Natural language specification at system level.
  - Hardware Description Languages at Chip, Register and Gate levels.
    - e.g. VHDL, Verilog
- Circuit Level
  - e.g. SPICE

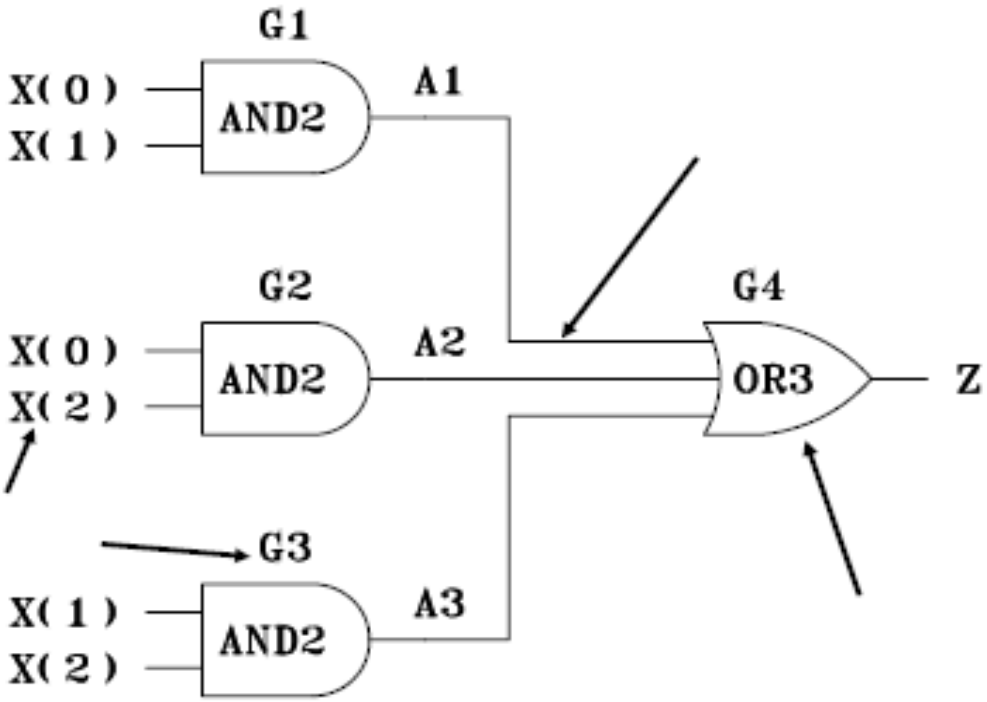
Graphical Editors

- Silicon Level editors are called Layout editors.
  - Draw rectangles describing metal, poly, diffusion etc
  - Library components are also at the same level.
  - Usually has online Design Rule Checking (DRC).
- Graphical Editors at other levels are usually called Schematic editors.
  - Used to create block diagrams and schematics.
  - The process is usually called *Schematic Capture*.

Schematic Editors

- Can create and display graphical components called “tokens”
- Can “interconnect” these tokens.
- Advantage :
  - Gives a structural representation called “netlist” describing the components used and their interconnections.
  - Also provides a simulation model to find the system’s response for different stimuli.

Example of Schematic Entry



Text based Design Entry

- Choose a specific HDL.
- Use text editors to describe the design.
  - e.g. vi, emacs, notepad etc.
  - Some tools have built-in editors
- Enter your design conforming to the language lexicon, syntax and semantics.
- Check for errors.
- “Compile” to get a simulation model.

What makes HDLs Different ?

- Hardware systems are concurrent in nature.
- Hardware systems may be distributed in nature.
  - Many components
  - Different rates for processing data, different clocks.
- Hardware systems are timed.
  - All hardware components have inherent delays and hence managing timing is crucial.
- Traditional software design techniques are insufficient.

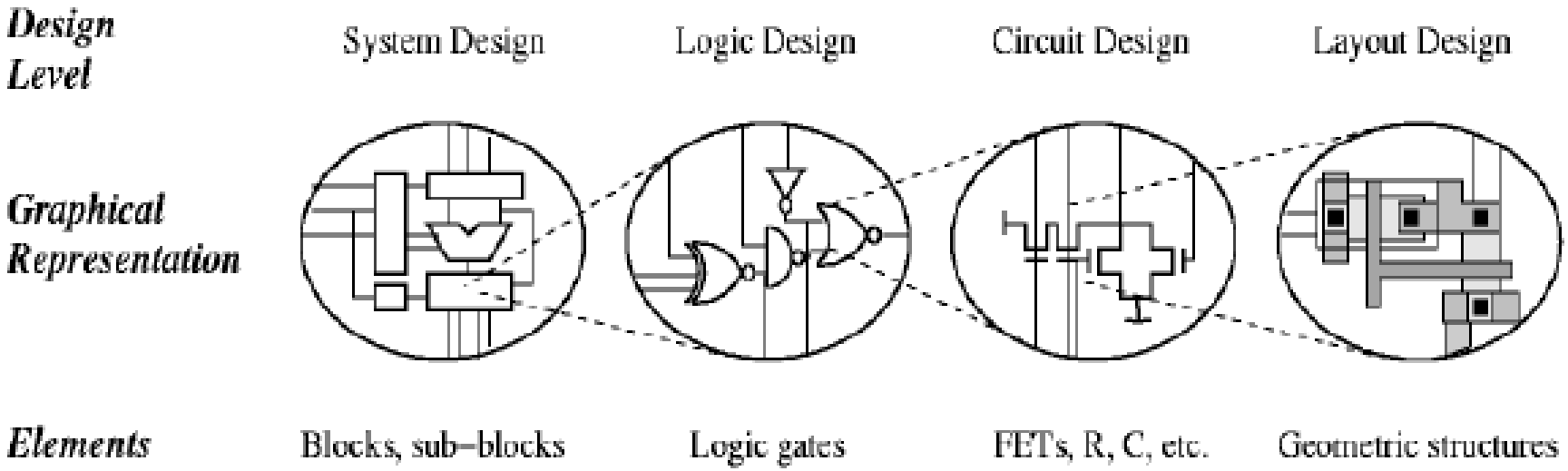
CAD Tools -2 Simulators

- Defn. : A program that models response of a system to the input stimuli.
- Simulation is widely used to establish design correctness.
- Types
  - Deterministic
  - Stochastic

CAD Tools -3 Synthesis Tools

- Synthesis Definition : Transformation of a representation in one hierarchical level to another.
- Different names in different levels :
  - Algorithmic Synthesis – Abstract behavioral to register level or gate level specification
  - Logic Synthesis – RTL specification to gates
  - Physical Synthesis – Structural specification as gates to layout.

Synthesis at different Levels



Synthesis Transformations