Synthesis of Digital Systems
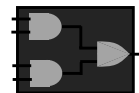## CS 411N / CSL 719
Part 2: Hardware Modelling

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Department of Computer Science and Engineering
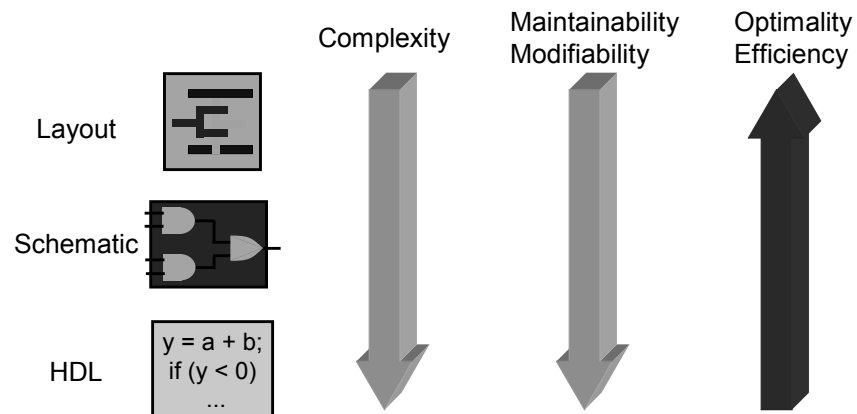
Indian Institute of Technology, Delhi

Specification

- Layout editor
  - directly enter layout
  - up to ~10^2 of unique transistors
  - complex circuits
    - memory, aided by generators
- Schematic Capture
  - enter gates and interconnections
  - up to ~10^4 transistors
- Hardware Description Languages
  - enter text description
  - ~10^7 transistors


```
y = a + b;
if (y < 0)
  ...
```

Specification Levels

Complexity   Maintainability Modifiability   Optimality Efficiency

Layout

Schematic

HDL
```
y = a + b;
if (y < 0)
   ...
```

Efficiency vs. Time-to-Market

- Efficiency more important for high-performance designs
  - processors, memory
  - high volume, so cost is amortised
- Time-to-market more important for most other classes of designs
  - consumer electronics
  - efficiency can be sacrificed

Requirements for Hardware Description Languages - 1

- Time
  - how the behaviour of the system changes with time
  - creating waveforms

Requirements for Hardware Description Languages - 2

- Periodic Signals
  - clocks

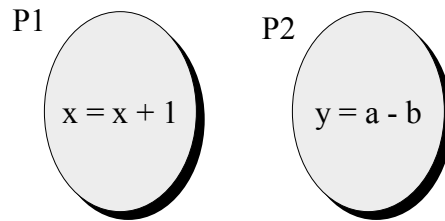# Requirements for Hardware Description Languages - 3

- Concurrency

P1

P2

$x = x + 1$

$y = a - b$
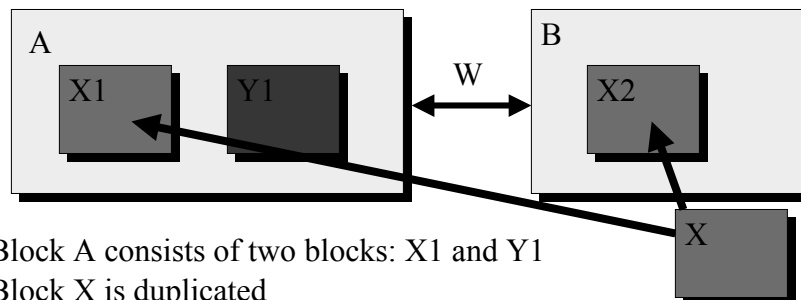
Specify: Processes P1 and P2 execute in parallel

Requirements for Hardware Description Languages - 4

- Structure, composition, and interconnection

A

X1   Y1

W

B

X2

X

Block A consists of two blocks: X1 and Y1
Block X is duplicated
Wire W connects A and B

Requirements for Hardware Description Languages - 5

- Bit-true data types
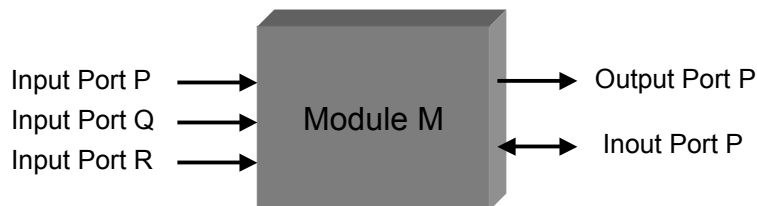 - Not so important in SW
  - Important in HW

  int<6:0> var;

  Specify the bit-width of variables

Requirements for Hardware Description Languages - 6

- Modules and Interfaces
  - Ports

Input Port P →
Input Port Q →   Module M   → Output Port P
Input Port R →   ↔ Inout Port P

Requirements for Hardware Description Languages - 7

- Electrical Characteristics
  - Current Levels
  - Tristating
- Sensitivity
  - rising edge/falling edge

Requirements for Hardware Description Languages - 8

- Other programming constructs
  - Text and File I/O
    - useful in simulation/debugging