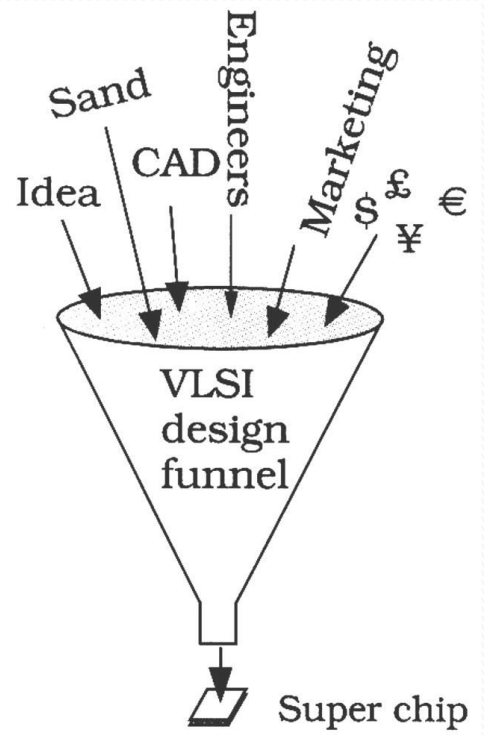
Unit 1
Design Hierarchy & Regularity, Modularity and Locality

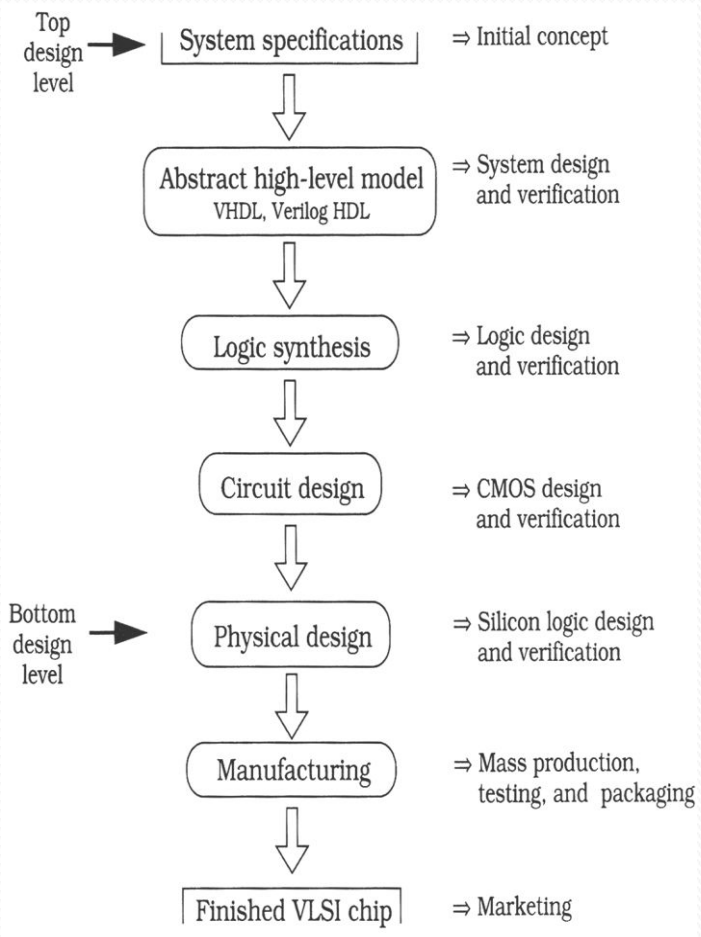
Complexity and Design

- Creating a design team provides a realistic approach to approaching a VLSI project, as it allows each person to study small sections of the system
  - Needing hundreds of engineers, scientists, and technicians
  - Needing *hierarchy design* and many different "*Level Views*"
  - Everyone of each level depends upon the Computer-Aided Design (CAD) tools



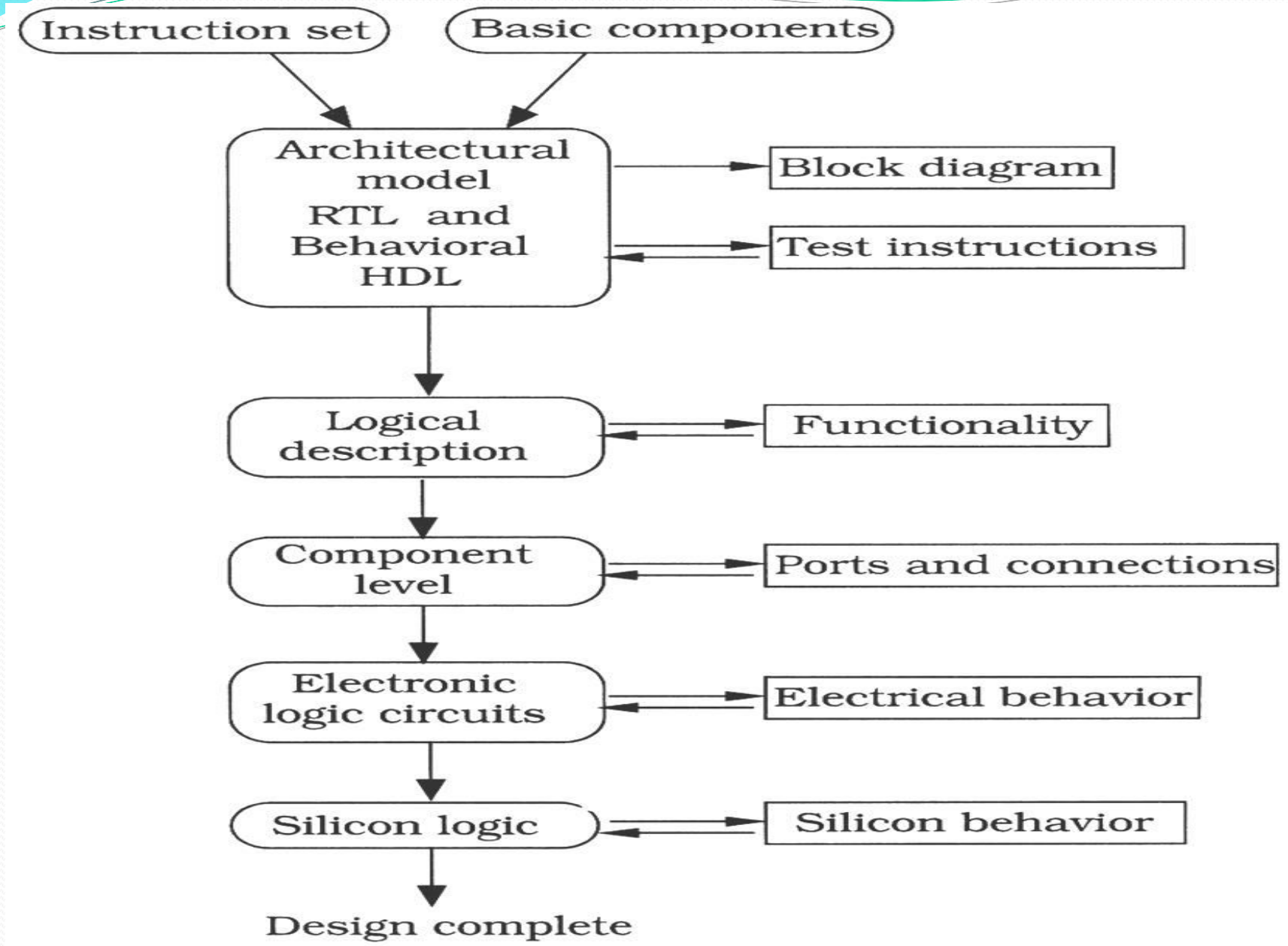
Design Hierarchy

- System specifications: is defined in both general and specific terms, such as *functions*, *speed*, *size*, etc.
- Abstract high-level model: contains information on the behavior of each block and the interaction among the blocks in the system
- Logic synthesis: To provide the logic design of the network by specifying the primitive gates and units needed to build each unit
- Circuit design: where transistors are used as switches and Boolean variables are treated as vary voltage signals
- Physical design: the network is built on a tiny area on a slice of silicon
- Manufacturing: a completed design process is moved on to the manufacturing line

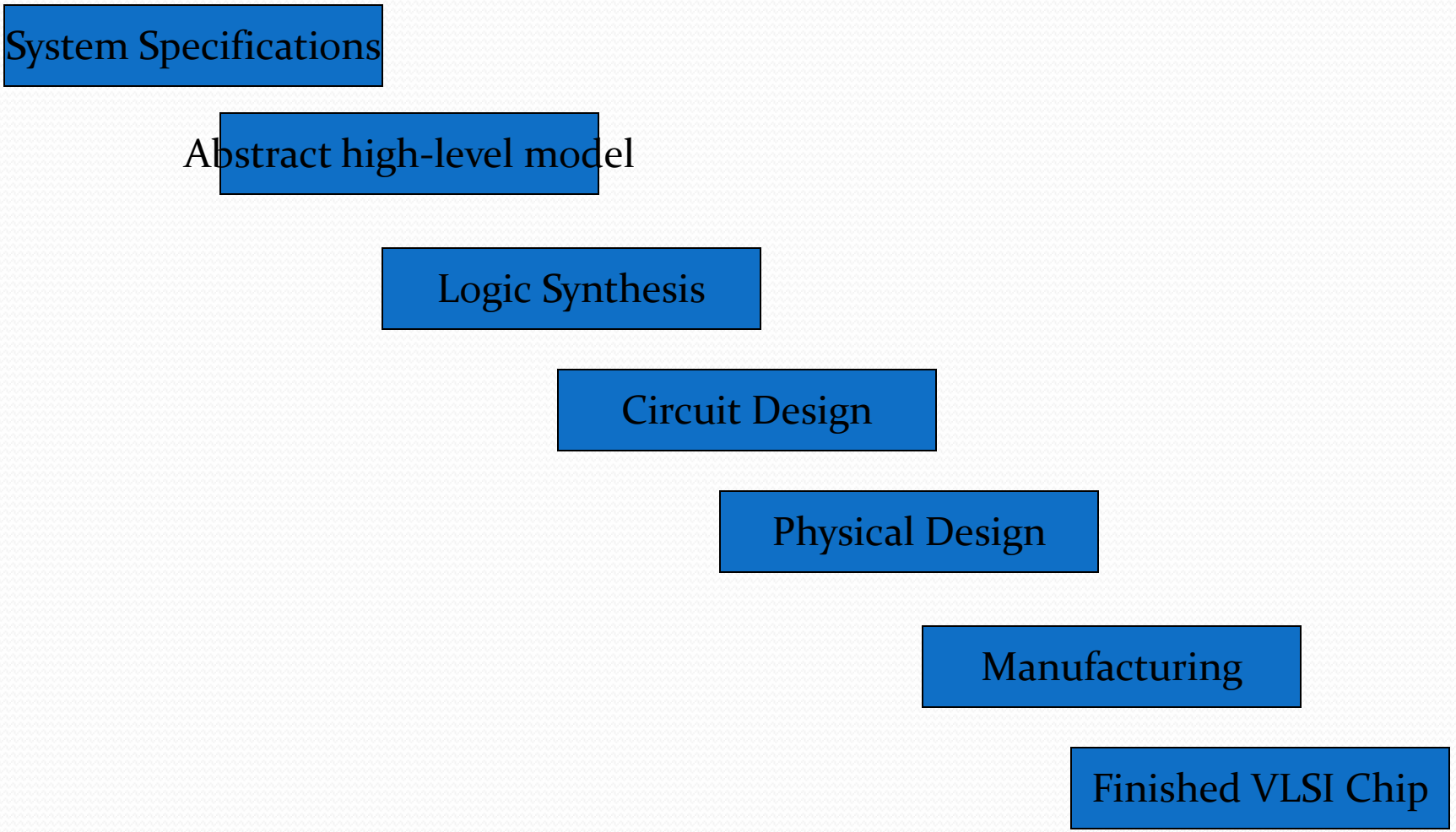


Design Hierarchy

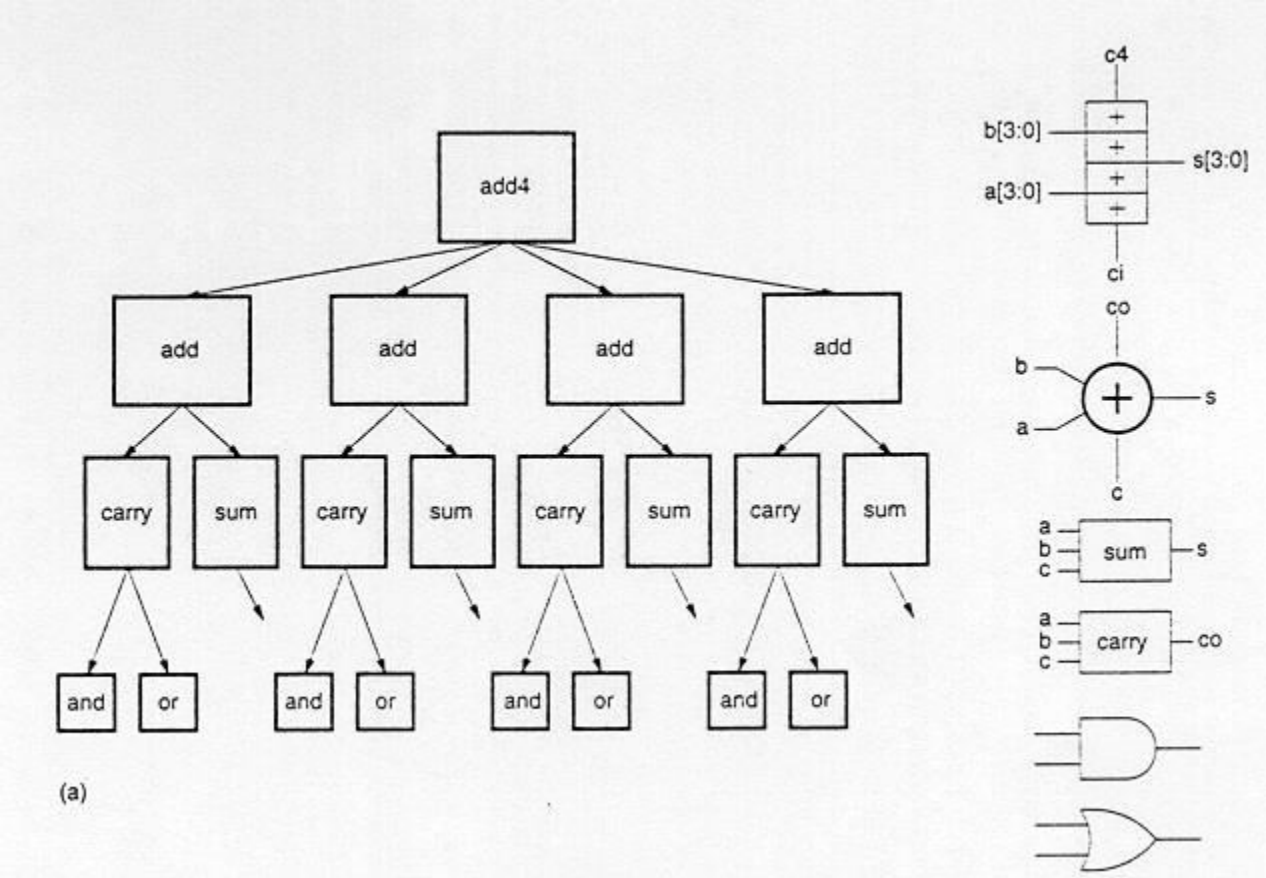
- **Hierarchical design**
  - **Top-down design**
    - The initial work is quite abstract and theoretical and there is no direct connection to silicon until many steps have been completed
    - Acceptable in modern digital system design
    - Co-design with combining HW/SW is critical
    - Similar to *Cell-based Design Flow*
  - **Bottom-up design**
    - starts at the silicon or circuit level and builds primitive units such as logic gates, adders, and registers as the first steps
    - Acceptable for small projects
    - Similar to *Full-custom Design Flow*


Instruction set
Basic components
Architectural model RTL and Behavioral HDL
Block diagram
Test instructions
Logical description
Functionality
Component level
Ports and connections
Electronic logic circuits
Electrical behavior
Silicon logic
Silicon behavior
Design complete

Design Hierarchy



Design Hierarchy (Example)



- Based on “divide and conquer”
- Dividing a module into sub- modules and then repeating this operation on the sub-modules until the complexity of the smaller parts becomes manageable.
- In fig.,CMOS four-bit adder into its components.
- The adder can be decomposed progressively into one-bit adders, separate carry and sum circuits, and finally, into individual logic gates. At this lower level of the hierarchy, the design of a simple circuit realizing a well-defined Boolean function is much more easier to handle than at the higher levels of the hierarchy.

VLSI Chip Types

- At the engineering level, digital VLSI chips are classified by the approach used to implement and build the circuit
  - **Full-custom Design**: where every circuit is custom designed for the project
    - Extremely tedious
    - Time-consuming process
  - **Application-Specific Integrated Circuits (ASICs)**: using an extensive suite of CAD tools that portray the system design in terms of standard digital logic constructs
    - Including state diagrams, functions tables, and logic diagram
    - Designer does not need any knowledge of the underlying electronics or the physic of the silicon chip
    - Major drawback is that all characteristics are set by the architectural design
  - **Semi-custom Design**: between that of a full-custom and ASICs
    - Using a group of primitive predefined cells as building blocks, called *cell library*

Regularity, Modularity and Locality

- The hierarchical design approach reduces the design complexity by dividing the large system into several sub-modules. Usually, other design concepts and design approaches are also needed to simplify the process.

- **1) Regularity:**
- Decomposition of a large system in simple and similar blocks as much as possible.

- *Example:*

  Design of array structures consisting of identical cells - such as a parallel multiplication array.

- **2) Modularity:**

- Modularity in design means that the various functional blocks which make up the larger system must have well-defined functions and interfaces.
- Modularity allows that each block or module can be designed relatively independently from each other.
- All of the blocks can be combined with ease at the end of the design process, to form the large system.
- The concept of modularity enables the parallelisation of the design process.

- **3) Locality:**
- The concept of locality also ensures that connections are mostly between neighboring modules, avoiding long-distance connections as much as possible.