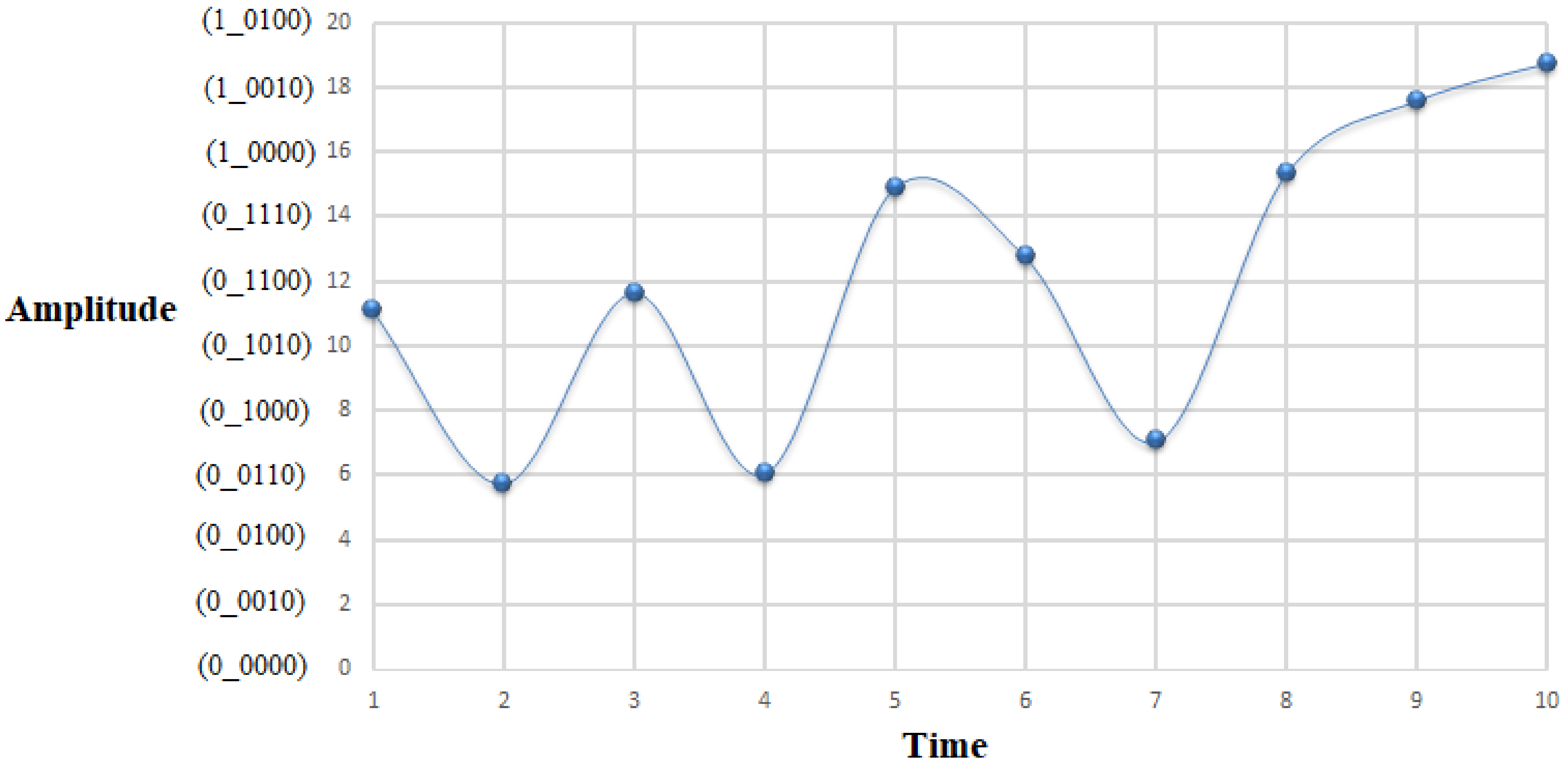
Digital System

Digital Signal Representation



- High Precision – Higher number of bits required

Digital Signal Representation

- Binary digit represents – logic HIGH or logic LOW
- In an electronic system – logic HIGH is 1, logic LOW is 0 or vice-versa
- 1 bit represents – 2 states
- 2 bits represents – 4 states – {00,01,10,11}
- n bits represents – 2^n states
- $2^{10} = 1024 \sim 1K$ bits
- $2^{20} = 10,48,576 \sim 1M$ bits

Analog and Digital Systems

- Analog systems process analog signals which can take any value within a range
  - Microphone, Analog meter display
- Digital systems process digital signals which can take only a limited number of values between two values
  - Flip-flops, Shift registers, Digital display

Advantage and Disadvantages of Digital Systems

- High accuracy (+)
- Programmability (+)
- Maintainability (+)
- Design Automation (+)
- Area, Power, Performance (-)

Introduction

- Rise in functionality increase design complexity
  - So, post design steps are automated using Computer Aided Design (CAD) tools
    - However, even designs using automated CAD tools may have bugs
  - Due to extremely large size of the design space it is not possible to verify correctness of the design under all possible situations
  - Techniques that can verify, without exercising exhaustive input-output combinations, that the design meets all the input specifications - *formal verification*

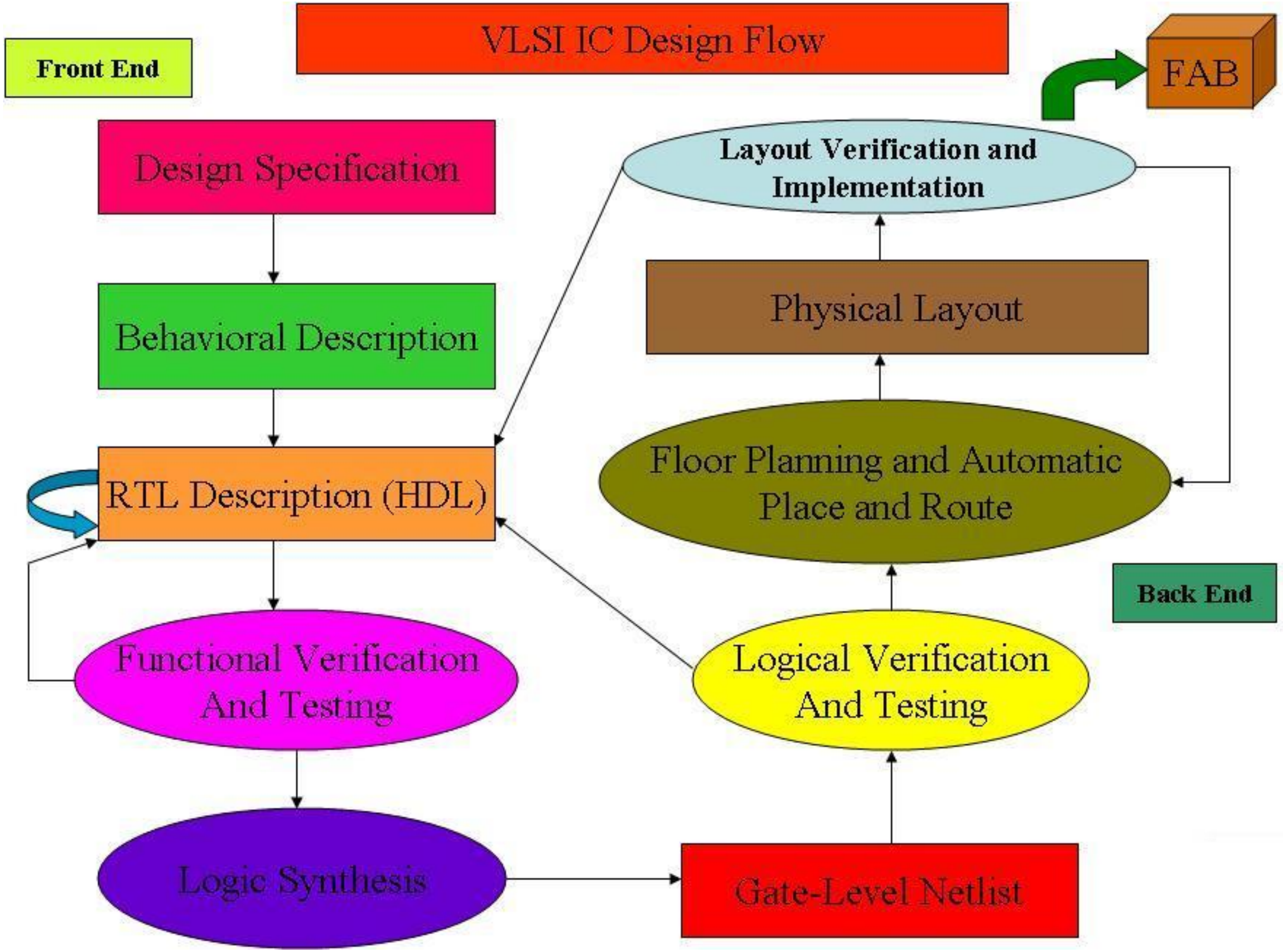
Introduction

- Manufacturing defect could arise due to decrease in the inter-component distance
- All the chips need to be physically tested by giving input signals from a pattern generator and comparing responses using a logic analyzer - *testing*.
- In the process of manufacturing a VLSI IC there are three broad steps
  - DESIGN
  - VERIFICATION
  - TEST
- Categorization of the IC's can be done based on the functionality
  - Analog, Digital or Mixed-signal
- Analog IC
  - Ex: Current mirrors, Voltage followers, filters, OPAMPs etc. work by processing continuous signals.
  - They perform functions like amplification, active filtering, demodulation etc.
- Digital IC
  - Ex: logic gates, flip-flops, multiplexers, and other circuits which work using binary mathematics to process "one" and "zero" signals.
- Mixed Signal IC
  - Ex: Analog to Digital Converter (ADC)

Introduction

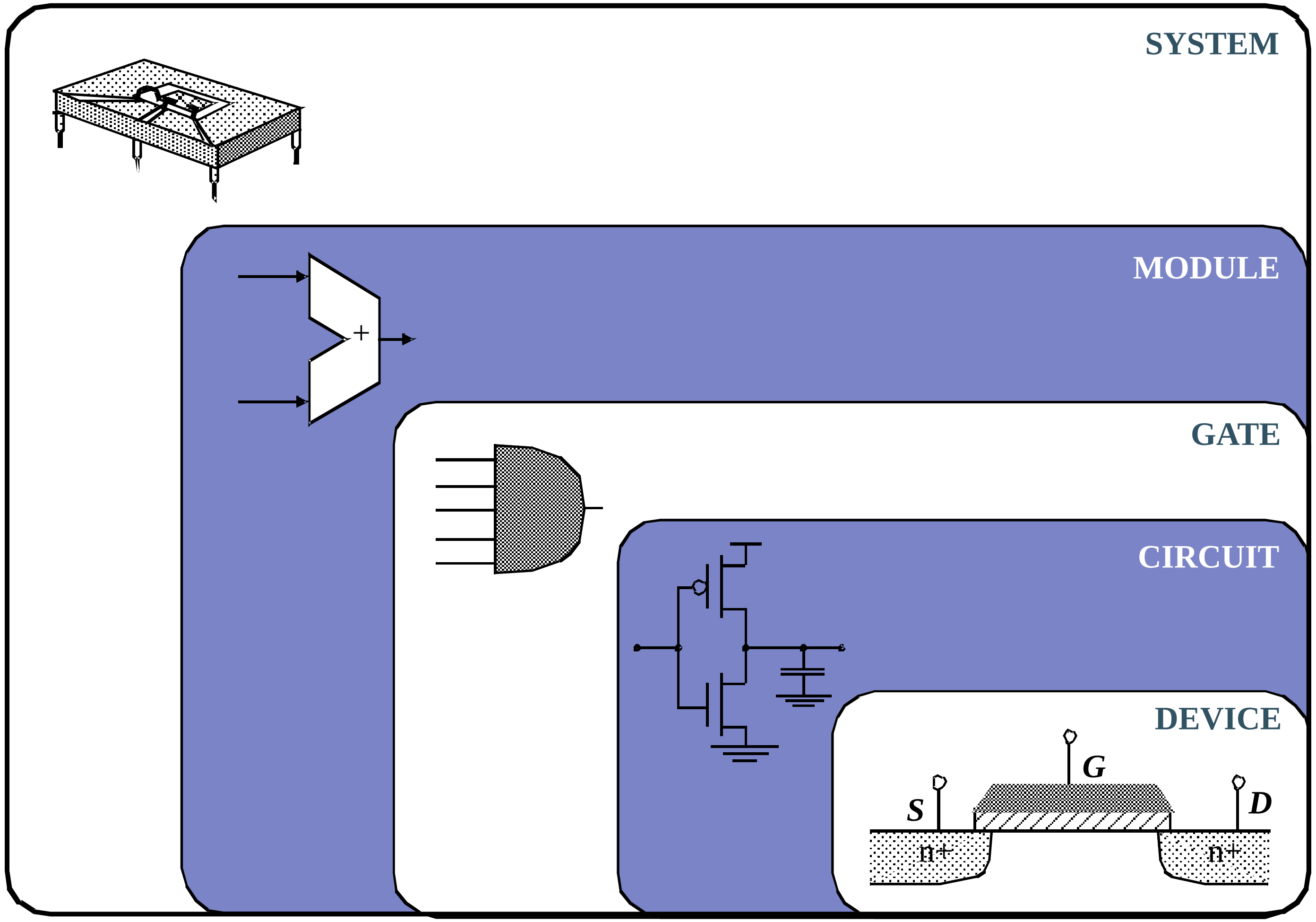
- Automation algorithms and CAD tools are mainly available for digital ICs
    - Digital circuits comprise millions of components and transformation of design specifications to silicon implementation can be accomplished using logical procedures
- Most of the analog circuits comprise less than hundred devices and its design is like an “art” which is best performed by designers with “aid” of some CAD tools

Introduction

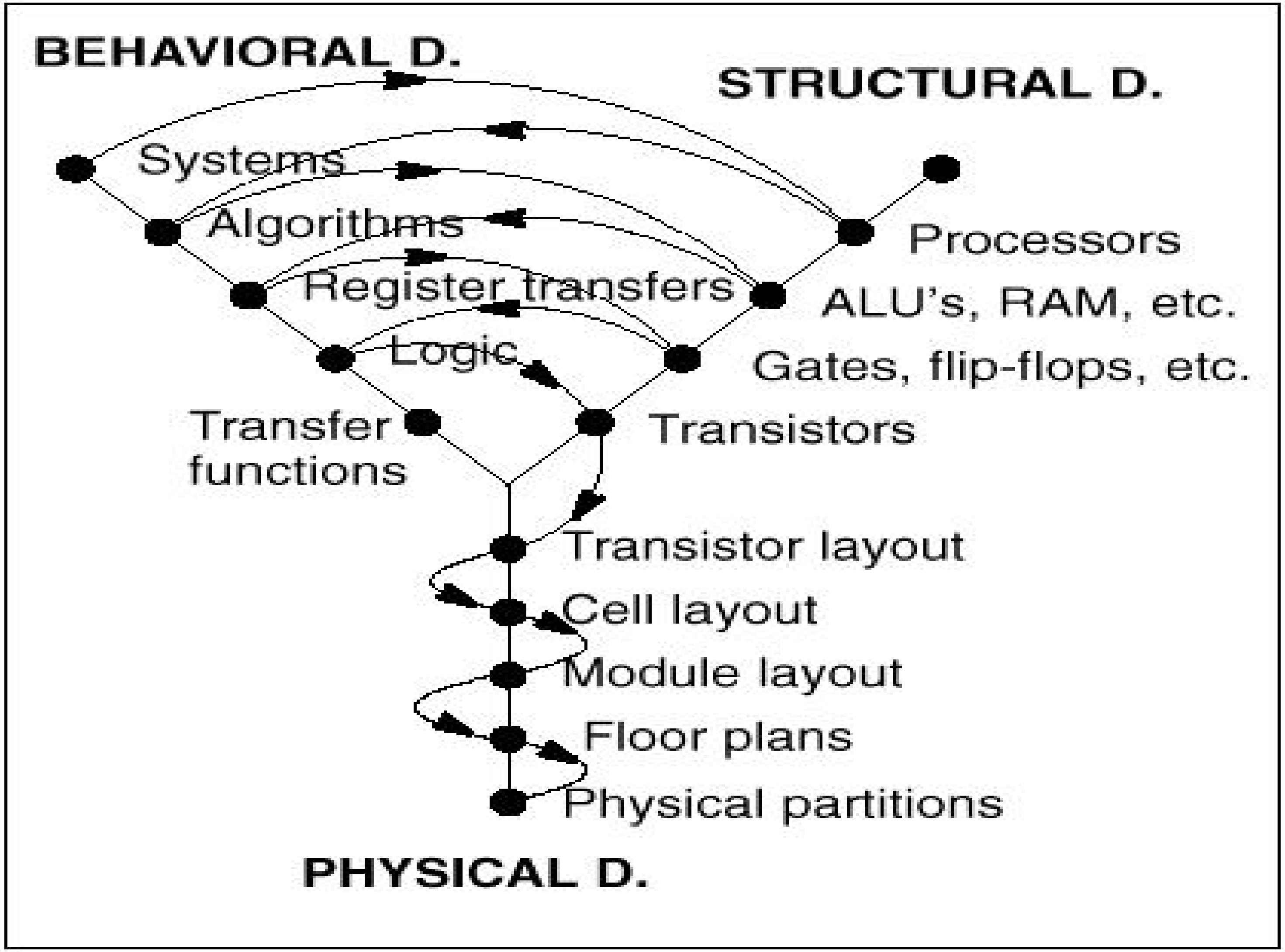


Introduction

Design Abstraction Levels



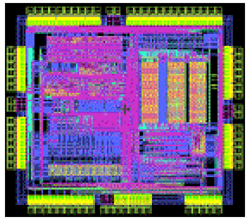
Introduction



Example: top-down structural decomposition and bottom-up layout construction

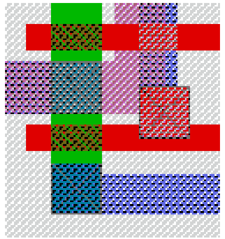
Introduction

Top-down design - Design complex circuits in a simple way

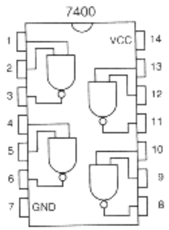


Architecture

Components

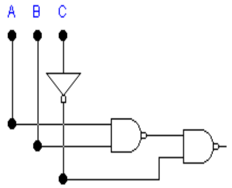


Gates



Transistors

Layout



IC

F=AB+C

Bottom-up analysis – Analyze simple components in a complex way

Introduction

- Functionality of electronics equipment and gadgets has increased but their physical size has come down drastically
  - Due to the rapid advances in integration technologies - millions of transistors in a single Integrated Circuit (IC) or chip.
- Small Scale Integration (SSI) - integration with 10's of transistors
- Medium Scale Integration (MSI) - integration with 100's of transistors
- Large Scale Integration (LSI) - integration with 1000's of transistors
- Very Large Scale Integration (VLSI) - integration with 1000's of transistors