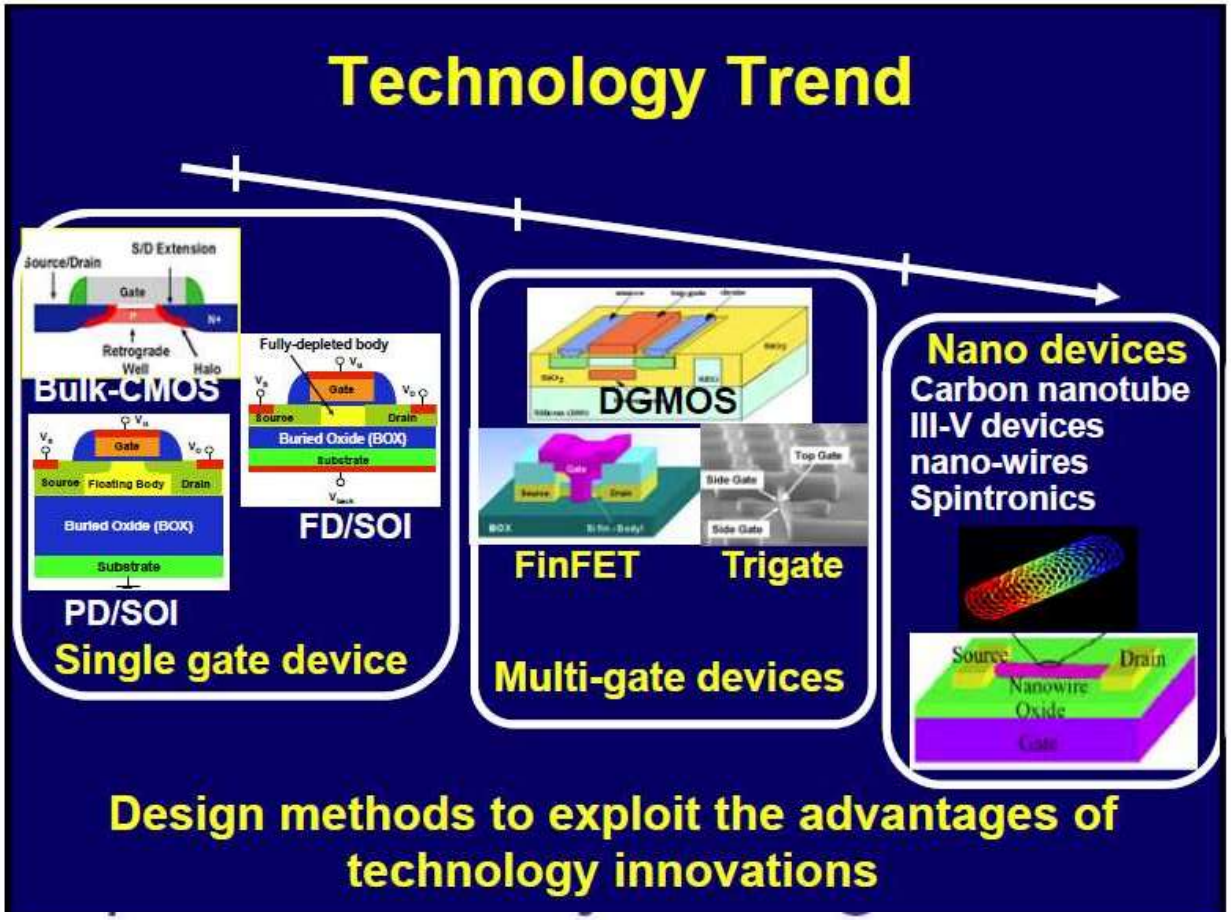



| Chip | IBM *P9*$^{TM}$ |
|---|---|
| Technology | 14nm FinFET SOI |
| No. Cores | 24 |
| Area | $695 mm^2$ |
| No. of Transistors | 8 Billion |

# VLSI System

- An electronic system composed of VLSI chips
- VLSI Chips
  - Very Large Scale Integration Chips
- Integration Complexity
  - Number of gates in a single chip

# Why Integrated Circuits?

- Integration Improves the Design
  - Physically small
- Integration Reduces Manufacturing Costs
  - Automated (Little manual assembly)
  - Less Packaging Cost
  - Less Testing Cost

# IC Evolution

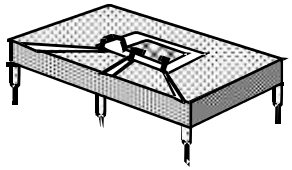
- SSI – Small Scale Integration
  - 10 gates per chip (1960's)
- MSI – Medium Scale Integration
  - 100 gates – 1000 gates per chip (1970's)
- LSI – Large Scale Integration
  - 1000 gates – 10,000 gates per chip (1980's)
- VLSI – Very Large Scale Integration
  - 10,000 gates – 1,00,000 gates per chip (1990's)
- ULSI – Ultra Large Scale Integration
  - 1M gates – 10M gates per chip (late 90's)
- GSI – Giant Scale Integration
  - 10M gates – 100M gates (early 2000's)

# Technologies - Evolution

- Bipolar technology
- MOS (Metal-oxide-silicon)
  - Although invented before bipolar transistor, was initially difficult to manufacture
  - nMOS (n-channel MOS) technology developed in 1970s required fewer masking steps, was denser, and consumed less power than equivalent bipolar ICs .
  - CMOS (Complementary MOS): n-channel and p-channel MOS transistors with lower power consumption, simplified fabrication process
- BiCMOS - hybrid Bipolar, CMOS

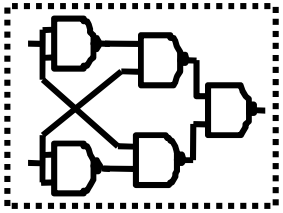
# VLSI Design Cycle

# VLSI Design Cycle



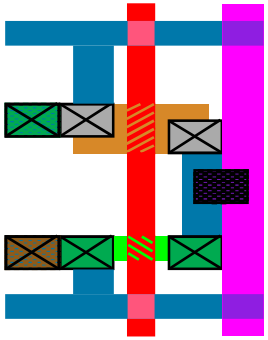
System Specifications

Architecture Design



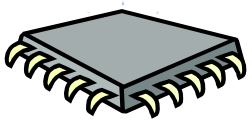
Logic Design

Circuit Design

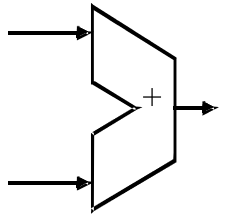


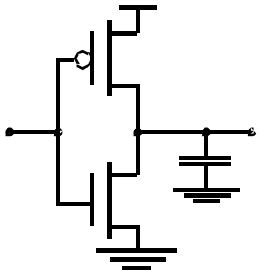
Physical Design

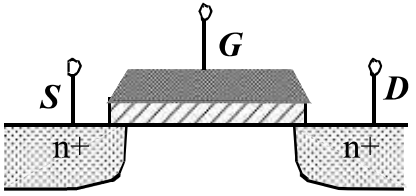
Fabrication



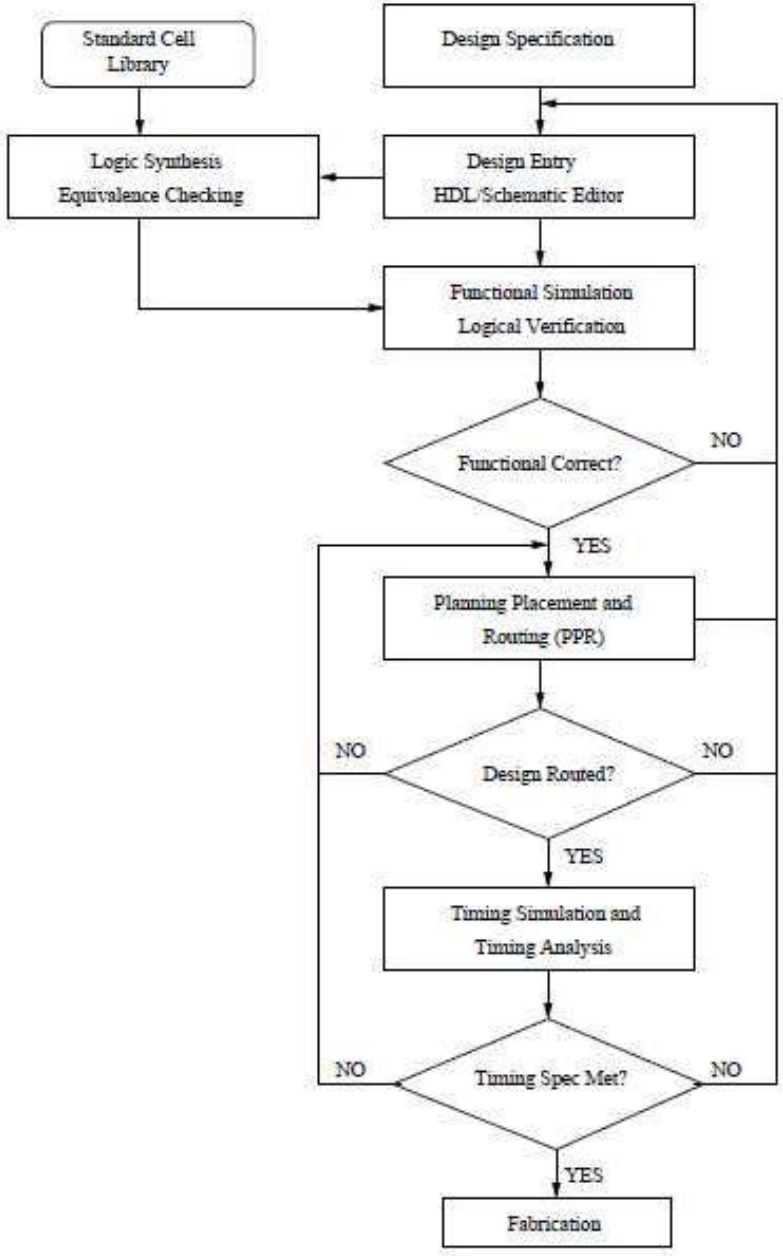
Packaging, Testing & Debugging



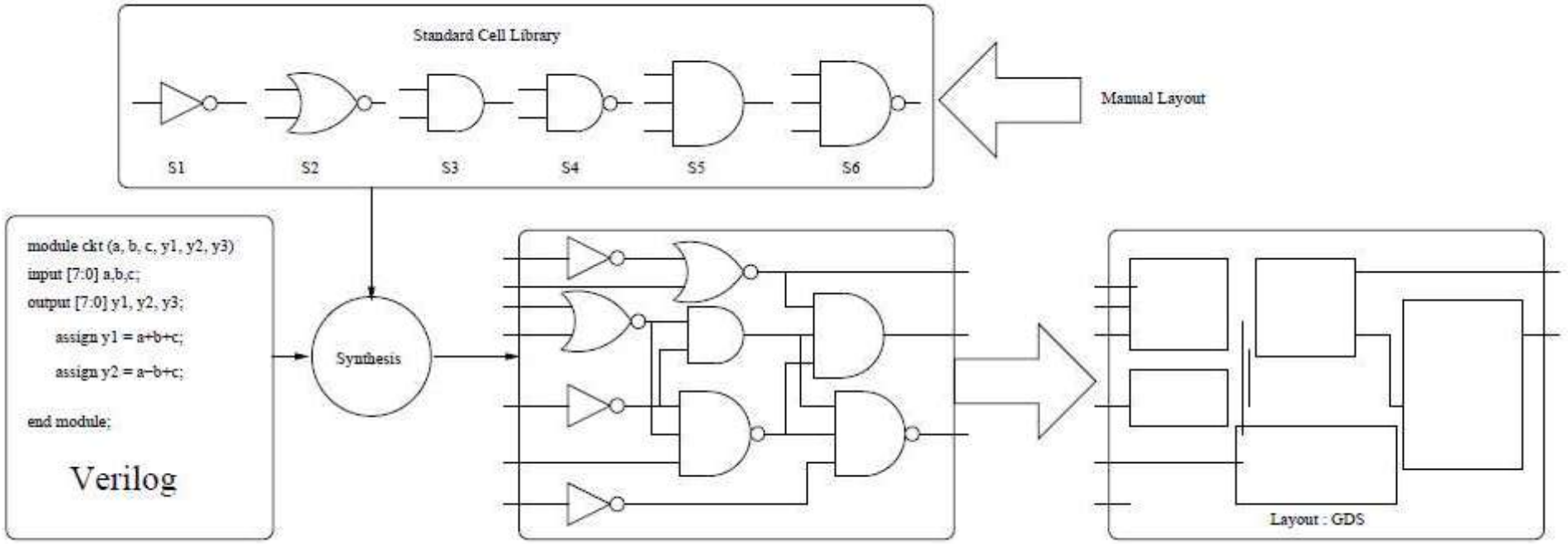




# VLSI Design Cycle



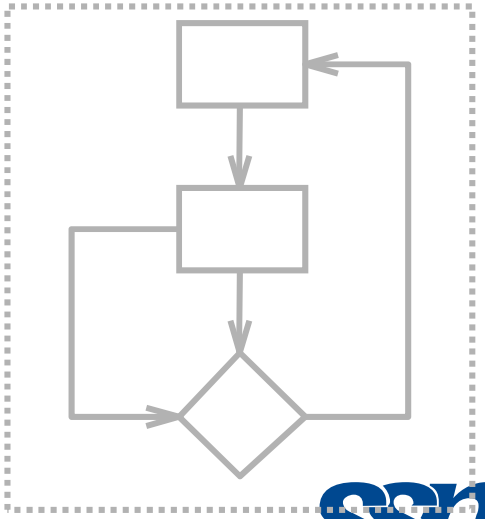
# VLSI Design Cycle



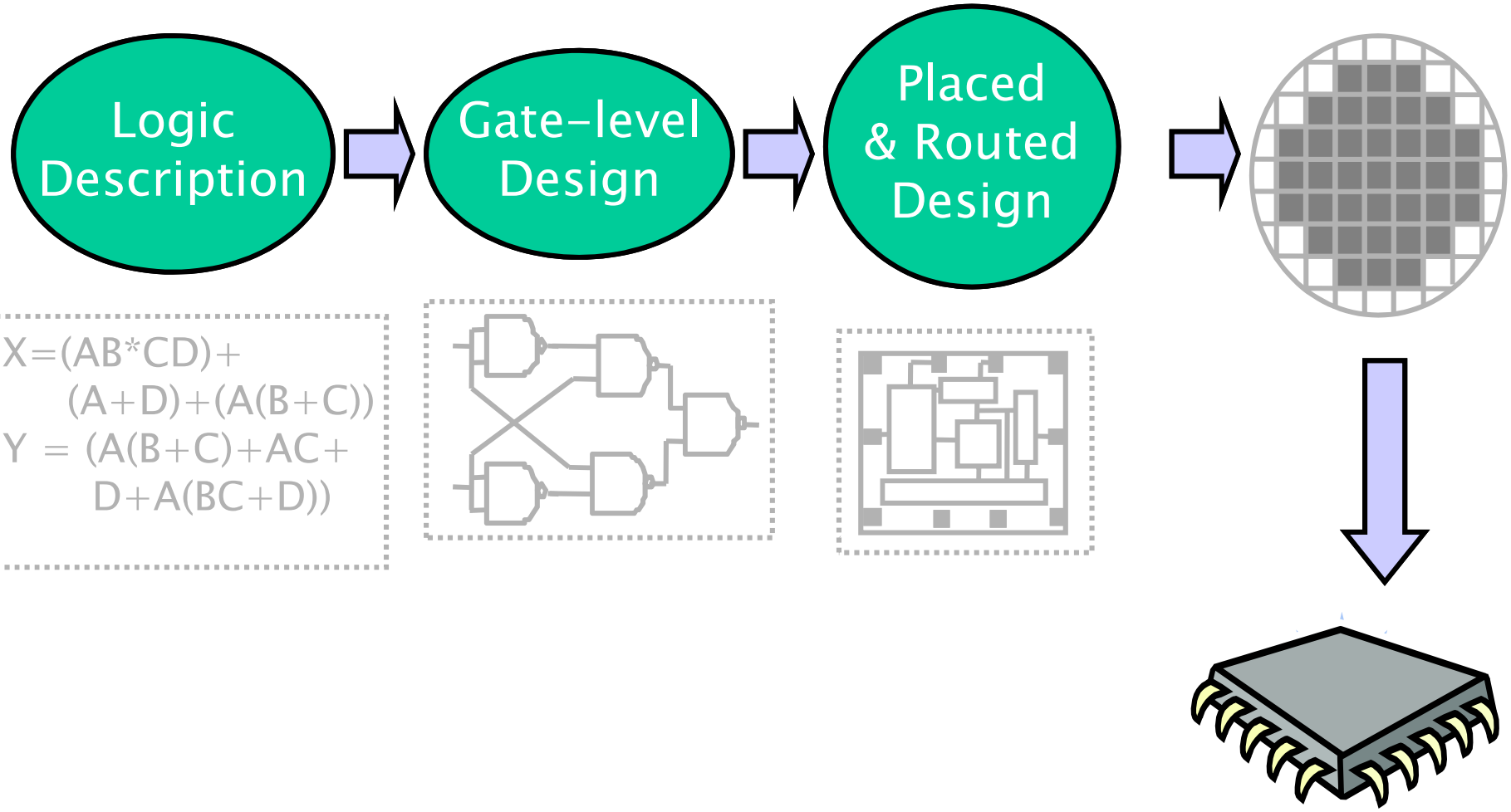
# Digital IC Design


Behavioral
VHDL, C

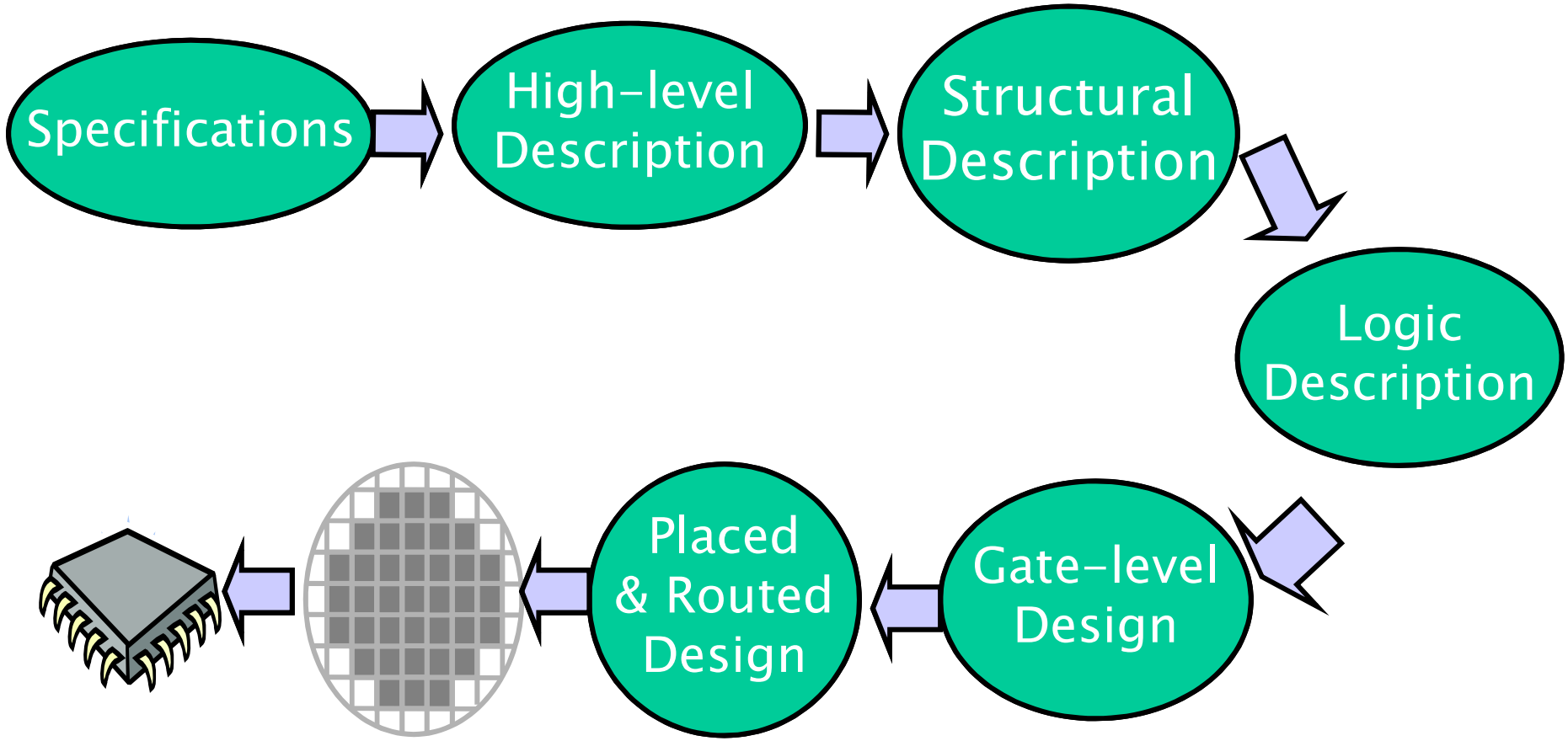
Structural
VHDL



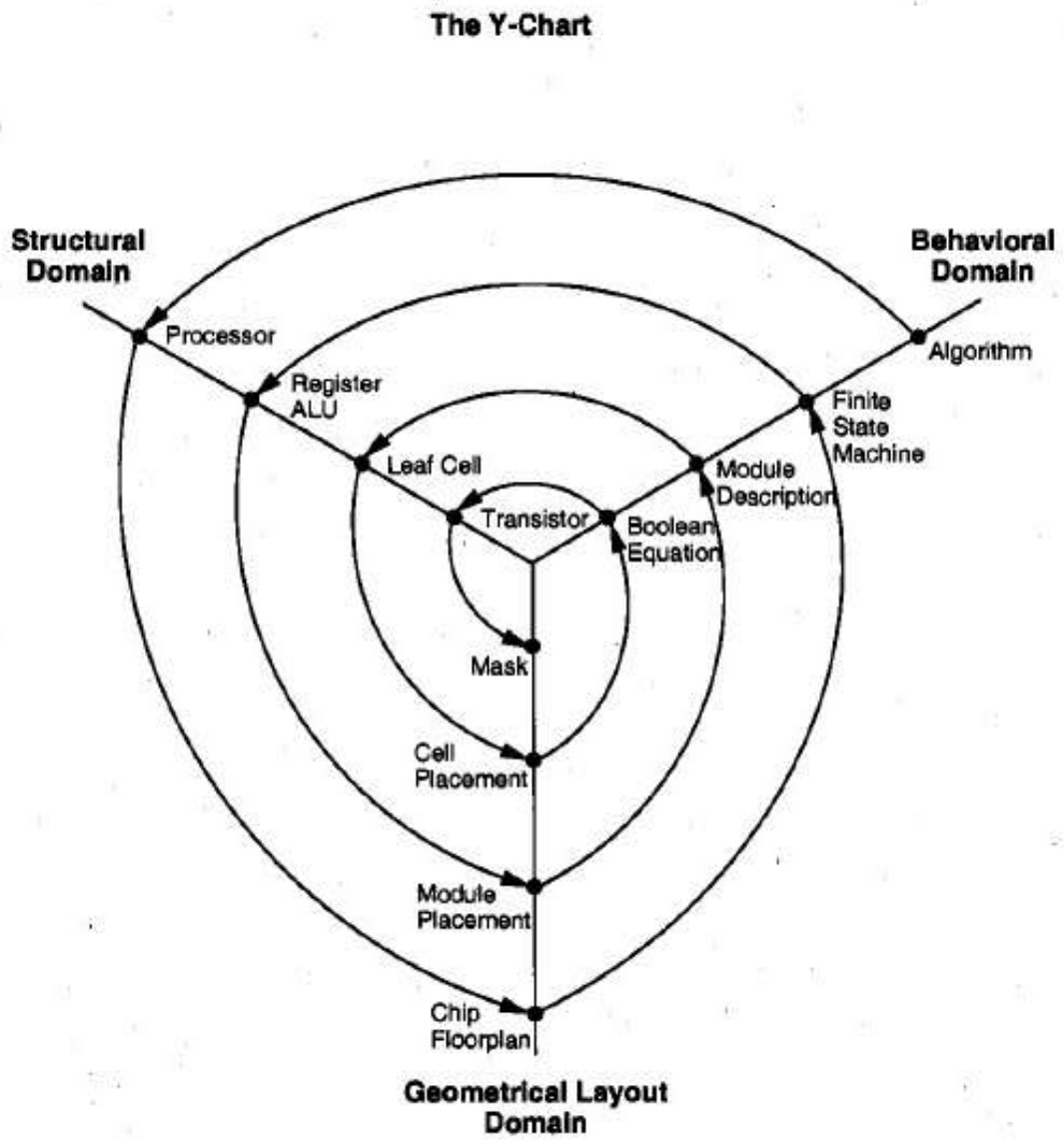
# Digital IC Design



# Digital IC Design

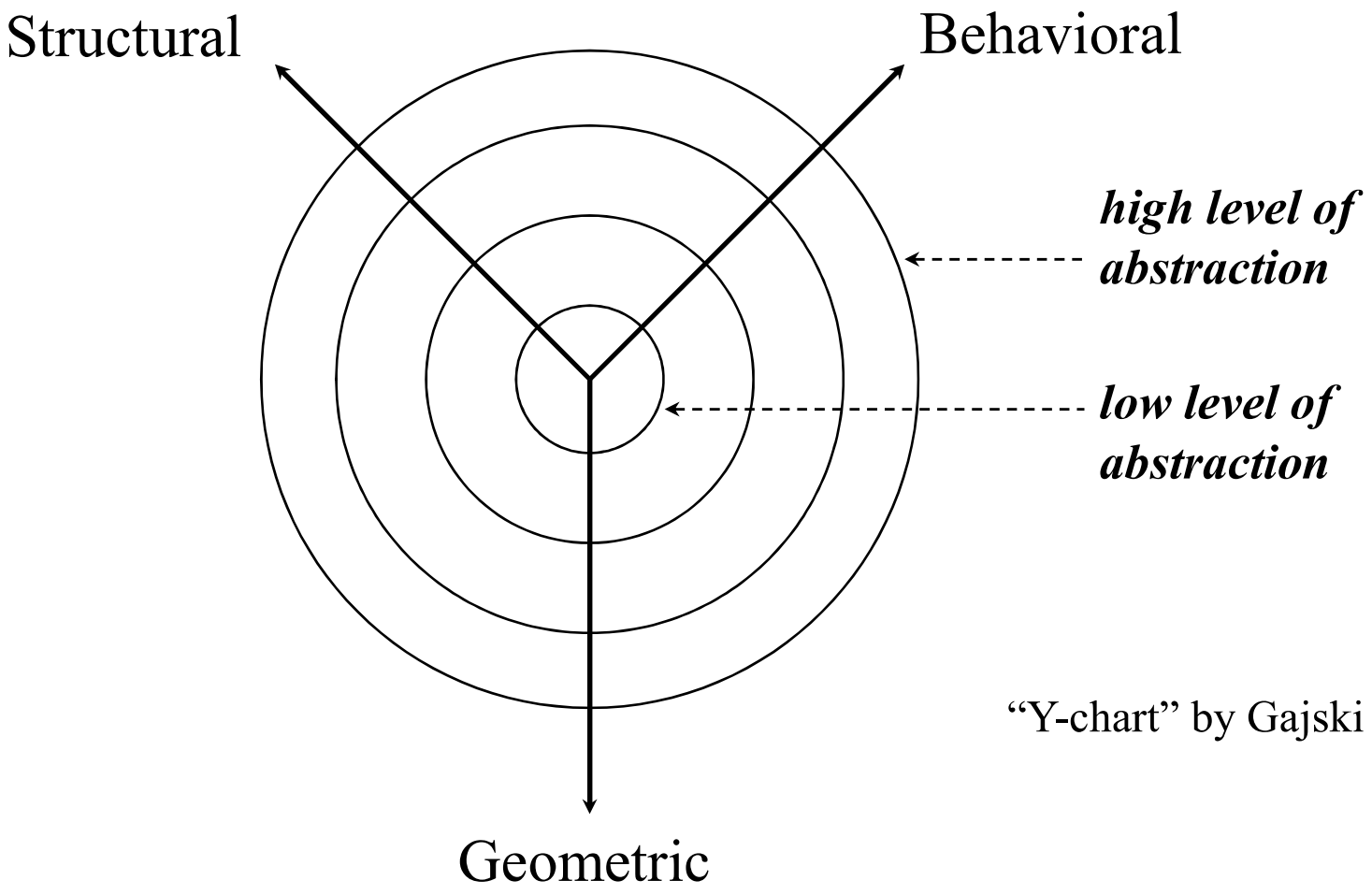


# Domains and Levels of Modeling




"Y-chart" by Gajski

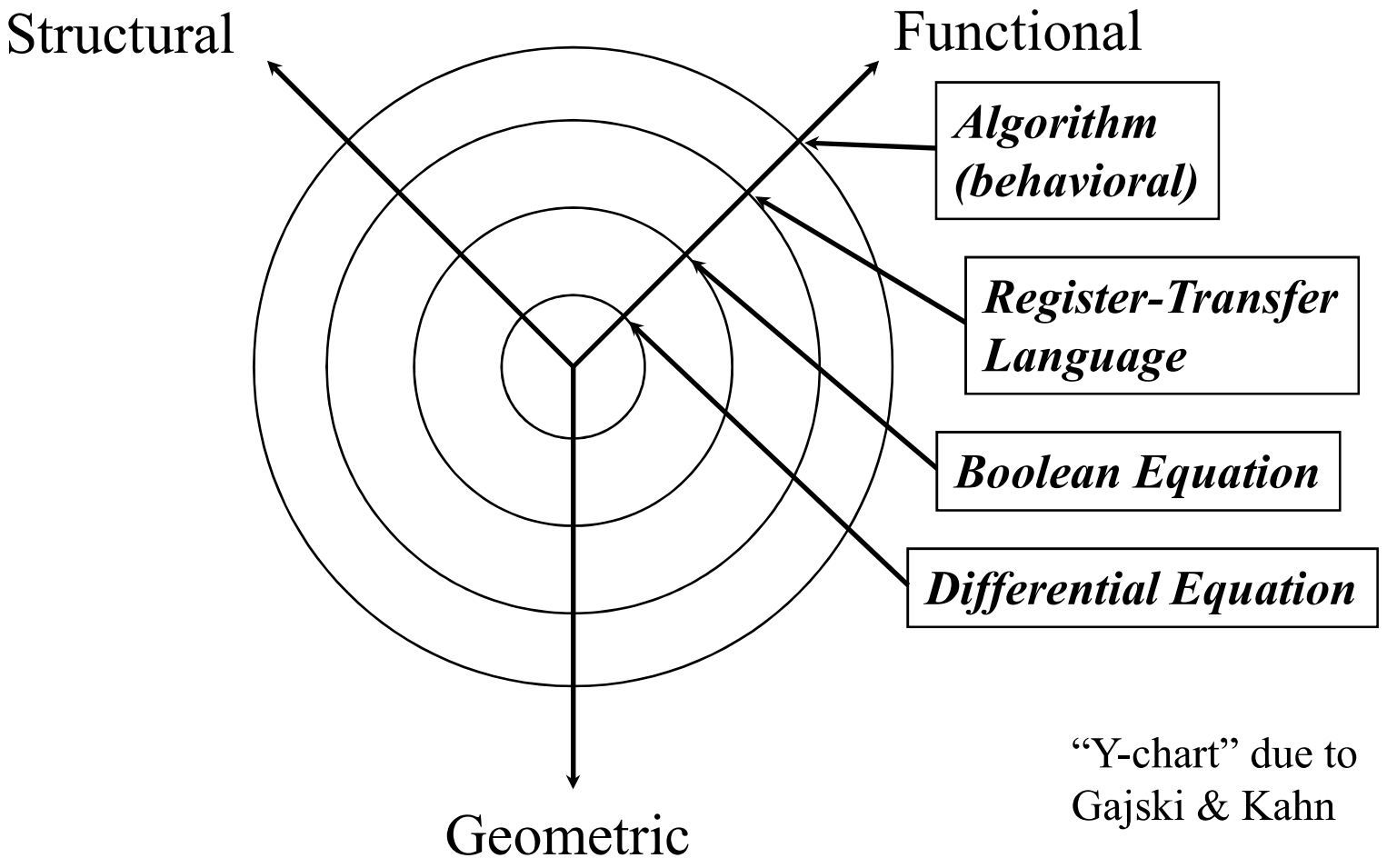
# Domains and Levels of Modeling




"Y-chart" by Gajski

**Gajski - "Y- Chart"**

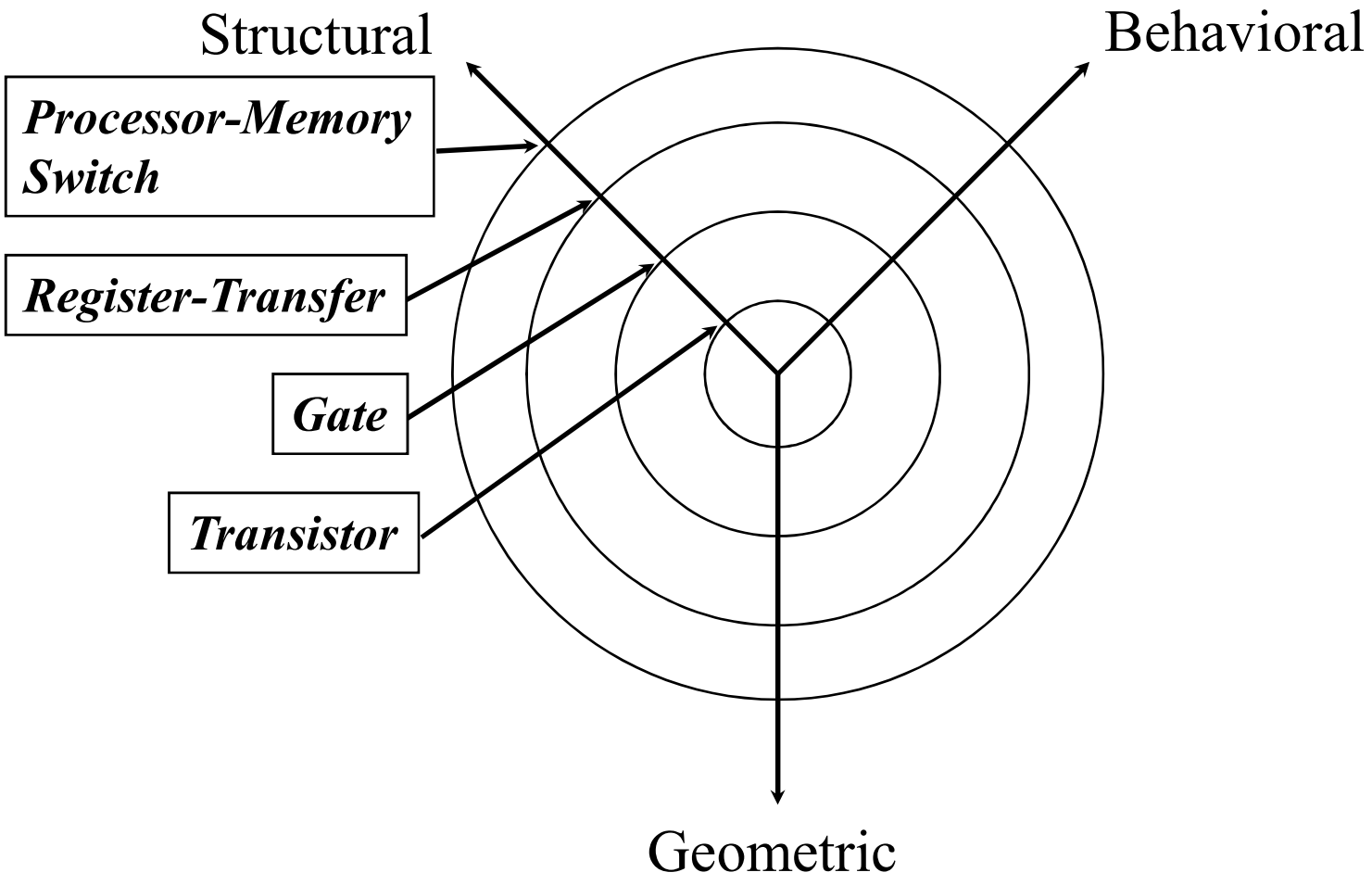
# Domains and Levels of Modeling




"Y-chart" due to Gajski & Kahn

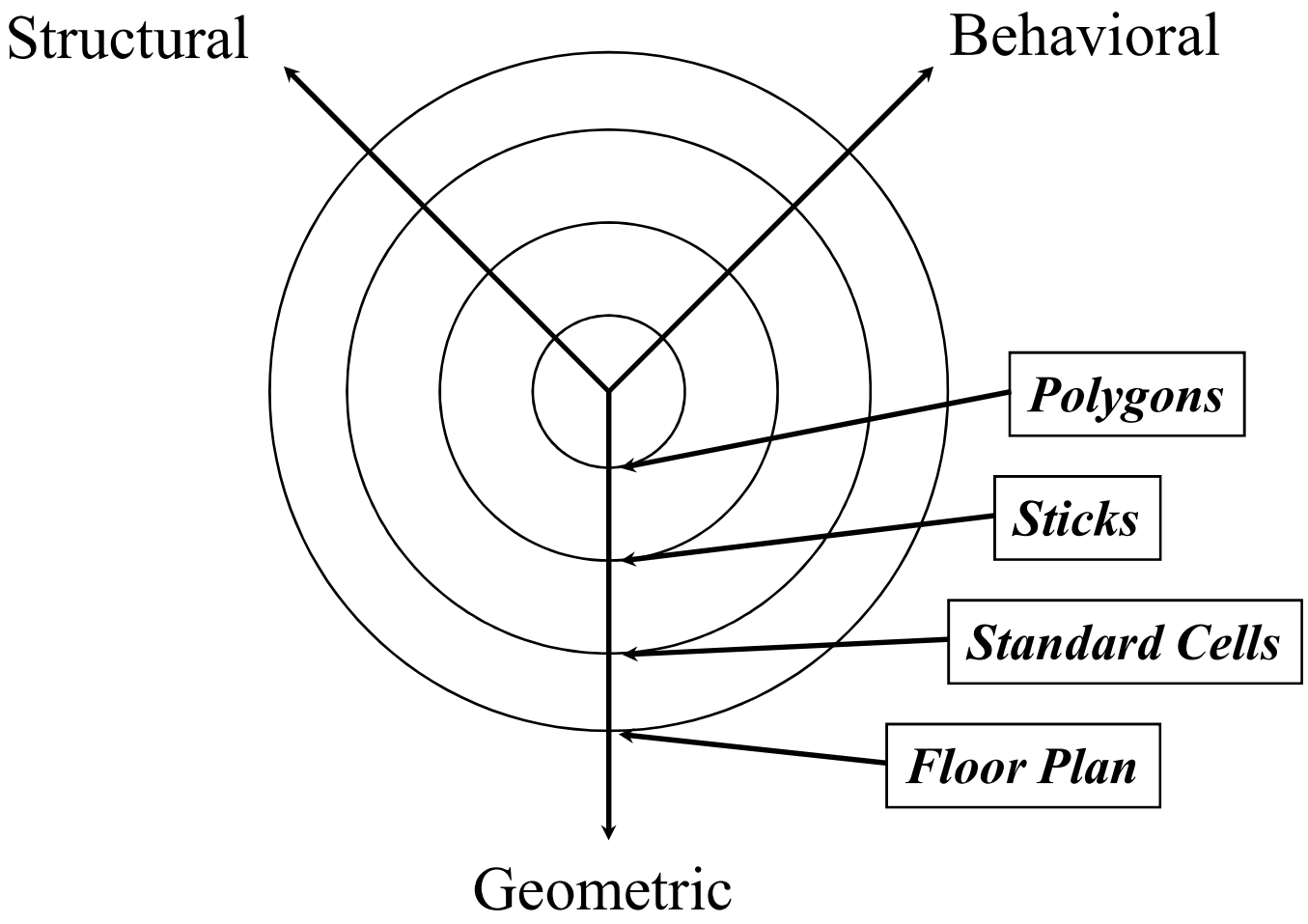
**Gajski - "Y- Chart"**

# Domains and Levels of Modeling




**Gajski - "Y- Chart"**

# Domains and Levels of Modeling



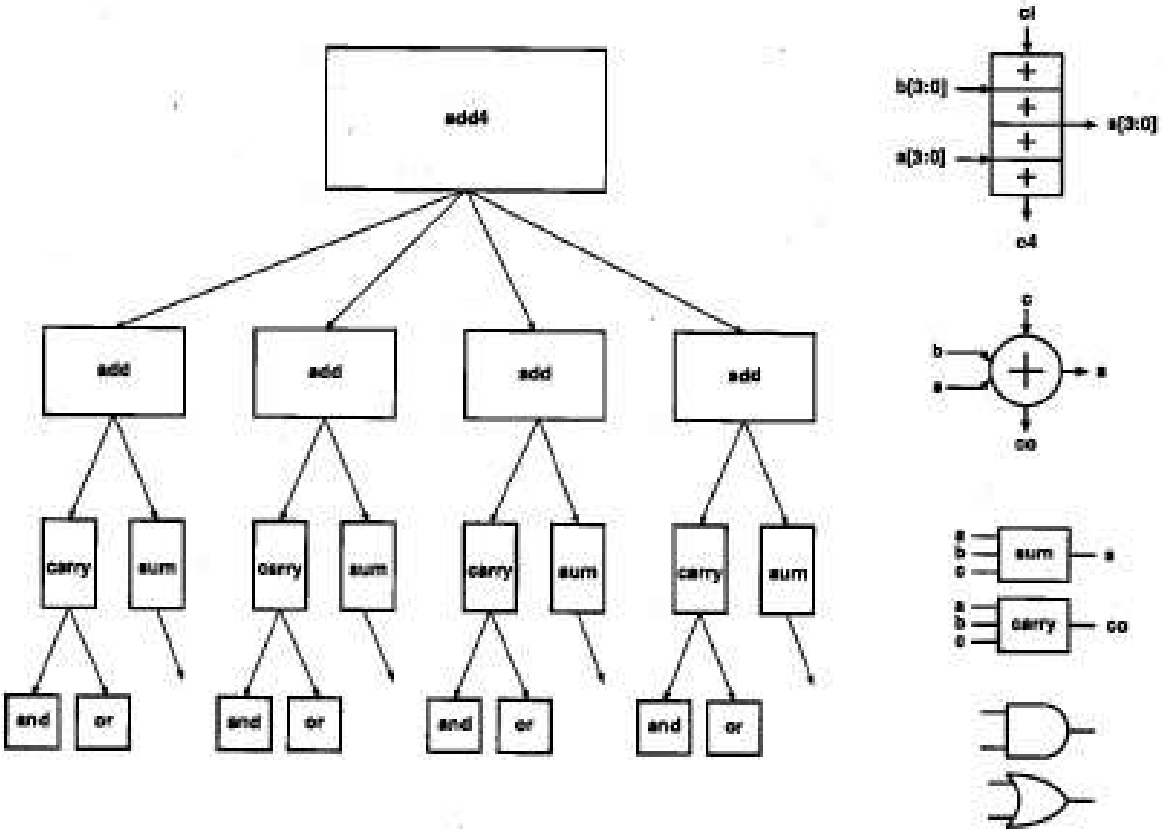

**Gajski - "Y- Chart"**

# VLSI Design Process

- Move from higher to lower levels of abstraction
- Use CAD tools to automate parts of the process
- Use hierarchy to manage complexity

# VLSI Design Hierarchy

- Hierarchy – Divide and conquer
- Divide a module into sub module and repeat this operation on sub module until the complexity becomes manageable.







Structural decomposition of 4 bit adder that shows the levels of hierarchy

# VLSI 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
- 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*

# 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.

**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 parallelization 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.

# Challenges in VLSI Design

- Increasing integration
  - To reduce cost, size and power dissipation

# Trends in VLSI

- Transistor
  - Smaller, faster, use less power
- Interconnect
  - Less delay, faster
- Yield
  - Smaller die size, higher yield

# VLSI Design Tradeoffs

- **Performance**
  - Area
  - Speed
  - Power Consumption
  - Time-to-Market