Lecture 1

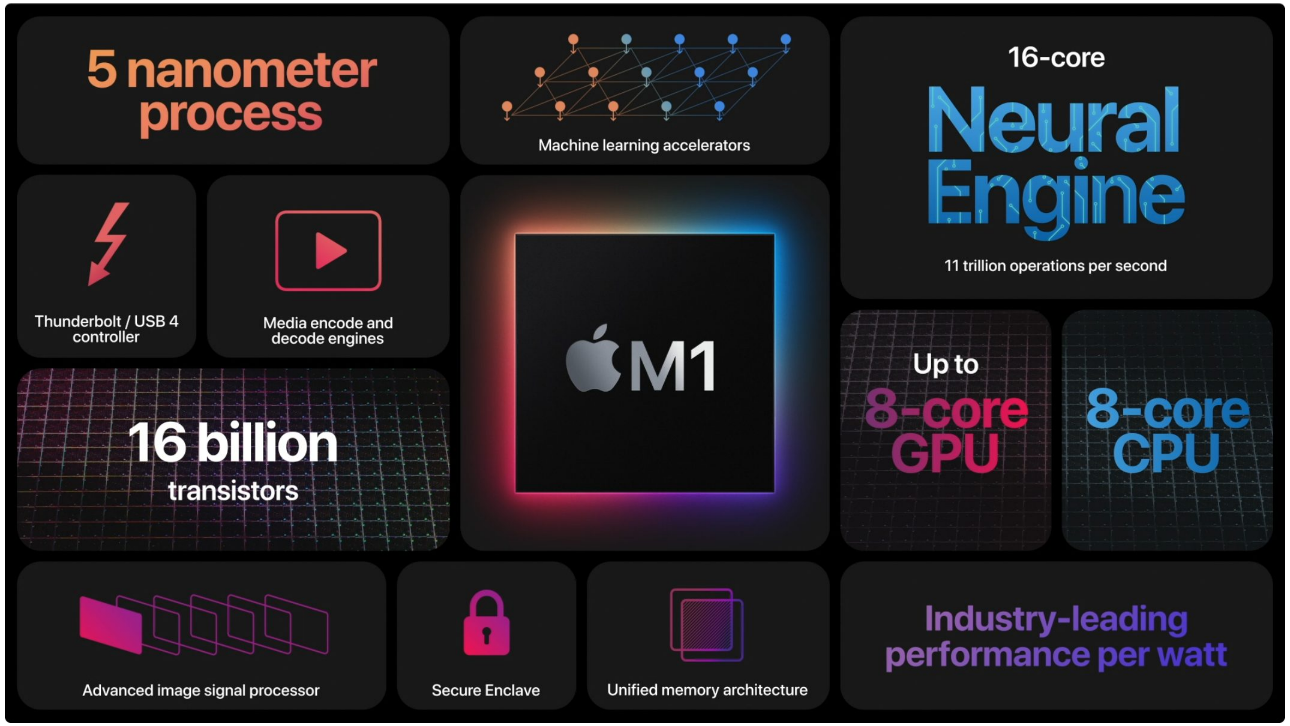
ASIC Design using Verilog/VHDL

(EC9036)

Introduction

- VLSI, or Very Large Scale Integration refers to a technology through which it is possible to implement large circuits in silicon - circuits with up to a million or even billions of transistors.
- Integrated circuits of the above complexity would not have been possible without the assistance of computer programs during all phases of the design process. These computer programs automate most of the design tasks. Designing a VLSI chip with the help of computer programs is known as CAD, or Computer Aided Design. Design Automation (DA), on the other hand, refers to entirely computerized design process with no or very little human intervention.

Example: Large Complex Design Idea → IC (chip)



Apple M1 chip (SoC)

16 billion transistors

Manufacturer: TSMC

CAD tools (Specialized Software for VLSI design)

- The design and optimization of *integrated circuits* (*ICs*) are essential to the production of new semiconductor chips. Modern chip design has become so complex that it is largely performed by specialized software, which is frequently updated to reflect improvements in semiconductor technologies and increasing design complexities.
- A *user* of this software needs a high-level understanding of the implemented algorithms.
- On the other hand, a *developer* of this software must have a strong computer science background, including a keen understanding of how various algorithms operate and interact, and what their performance bottlenecks are.

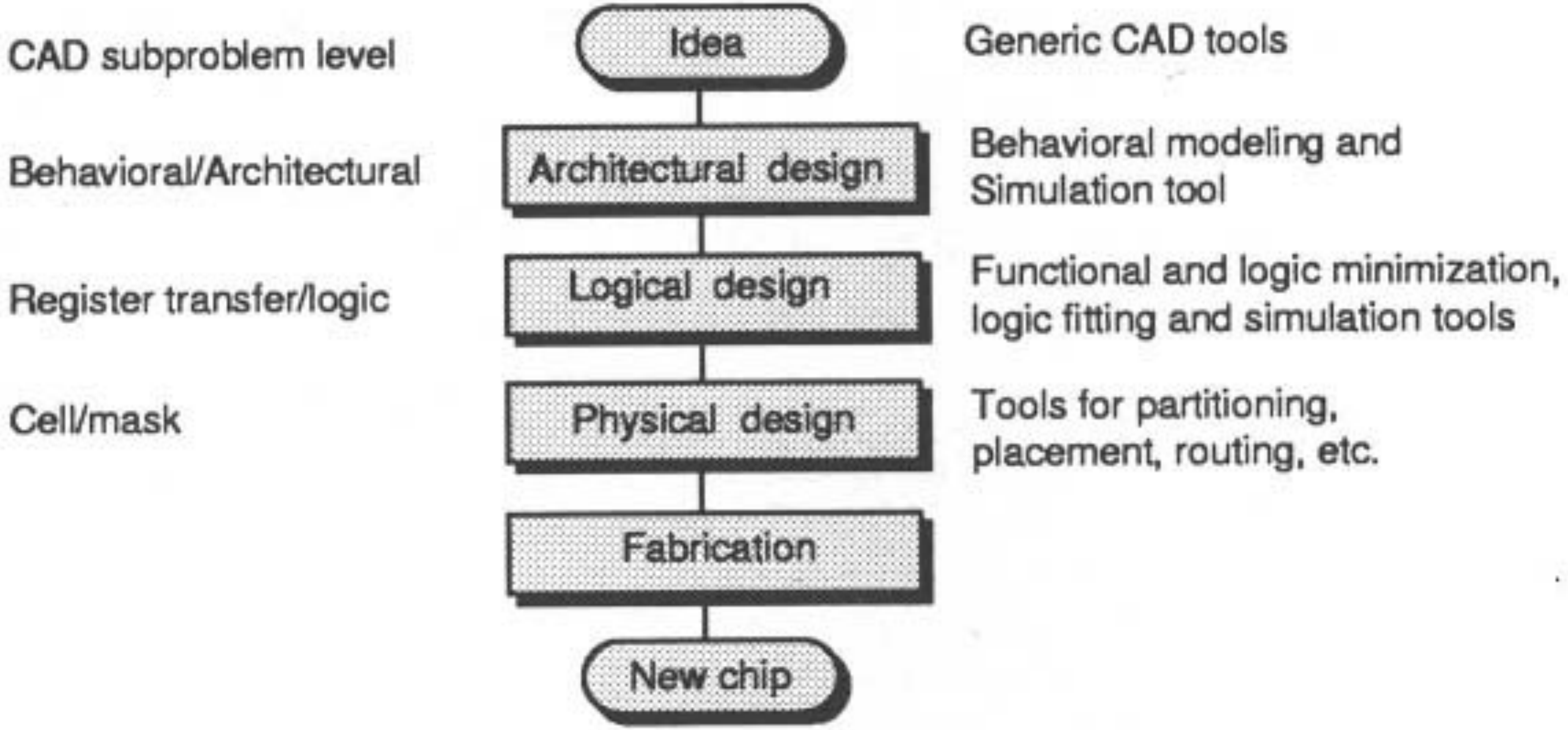
Electronic Design Automation (EDA)

- The Electronic Design Automation (EDA) industry develops software to support engineers in the creation of new integrated-circuit (IC) designs. Due to the high complexity of modern designs, EDA touches almost every aspect of the IC design flow, from high-level system design to fabrication.
- The largest EDA software vendors today are, in alphabetical order: Cadence Design Systems, Mentor Graphics, and Synopsys.

VLSI Design Process

- Since the complexity of VLSI circuits is in the order of millions of transistors, designing a VLSI circuit is understandably a complex task. In order to reduce the complexity of design process, several intermediate levels of abstractions are introduced.
- Typical levels of abstractions together with their corresponding design steps are illustrated in Figure (next slide). As indicated in Figure, the design is taken from specification to fabrication step by step with the help of various CAD tools. Clearly it is not possible to sit down with paper and pencil to design a million-transistor circuit (or chip).

VLSI Design Process



Step 1: Design idea (System specification)

Chip architects, circuit designers, product marketers, operations managers, and layout and library designers collectively define the overall goals and high-level requirements of the system. These goals and requirements span functionality, performance, physical dimensions and production technology.

Step 2: Architectural design

- Architectural design of a chip **is** carried out by expert human engineers. Decisions made at this stage affect the cost and performance of the design significantly.
- Suppose a new microprocessor has to be designed. Several examples of decisions made during the architectural design of a microprocessor are given below.

-What should be the instruction set of the processor? What memory addressing modes should be supported?

- Should instruction pipelining be employed?

- How will the processor interface to the external world? Are there

any international standards to be met?

Various others decisions might be taken at this stage.

Step 3: Logic design

- Once the architecture is set, the functionality and connectivity of each module (such as a processor core) must be defined. During functional design, only the high-level behaviour must be module has a set of inputs, outputs, and timing behaviour.
- Logic design is performed at the register-transfer level (RTL) using a hardware description language (HDL) by means of programs that define the functional and timing behaviour of a chip. Two common HDLs: Verilog and VHDL. All the HDL modules must be thoroughly simulated and verified.
- Logic synthesis tools automate the process of converting HDL into low-level circuit elements.

Step 4: Physical design

- Physical design of a circuit is the phase that precedes the fabrication of a circuit. In most general terms, physical design refers to all synthesis steps succeeding logic design and preceding fabrication.
- These include all or some of the following steps: logic partitioning, floorplanning, placement, and routing.
- The performance of the circuit, its area, its yield, and its reliability depend critically on the way the circuit is physically laid out.

- Converts a circuit description into a geometric descriptions (GDS2 format) which is used for fabrication of the chip.

VLSI Design Styles (Layout styles) → Physical design

- Selecting an appropriate circuit-design style is very important because this choice affects time-to-market and design cost. VLSI design styles fall in two categories – full-custom and semi-custom.
- Full-custom design is primarily seen with extremely high-volume parts such as microprocessors where the high cost of design effort is amortized over large production volumes.
- Semi-custom design is used more frequently because it reduces the complexity of the design process, and hence time-to-market and overall cost as well. The following semi-custom standard design styles are the most commonly used.

Cell-based: typically using standard cells and macro cells, the design has many pre-designed elements such as logic gates that are copied from libraries.

Array-based: typically either gate arrays or FPGAs, the design has a portion of pre-fabricated elements connected by pre-routed wires.