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Digital Design

Introduction

Digital Design Principle

- Number systems
- Boolean algebra
- Switch and CMOS design
- Combinational logic
  - Logic gates
  - Building blocks: de/mux, de/encoder, shifters, adder/subtractor, multiplier
  - Logic minimization
  - Mixed logic
- Sequential logic
  - Latches, Flip-flops
  - Counters
  - State machines: Mealy/Moore machines

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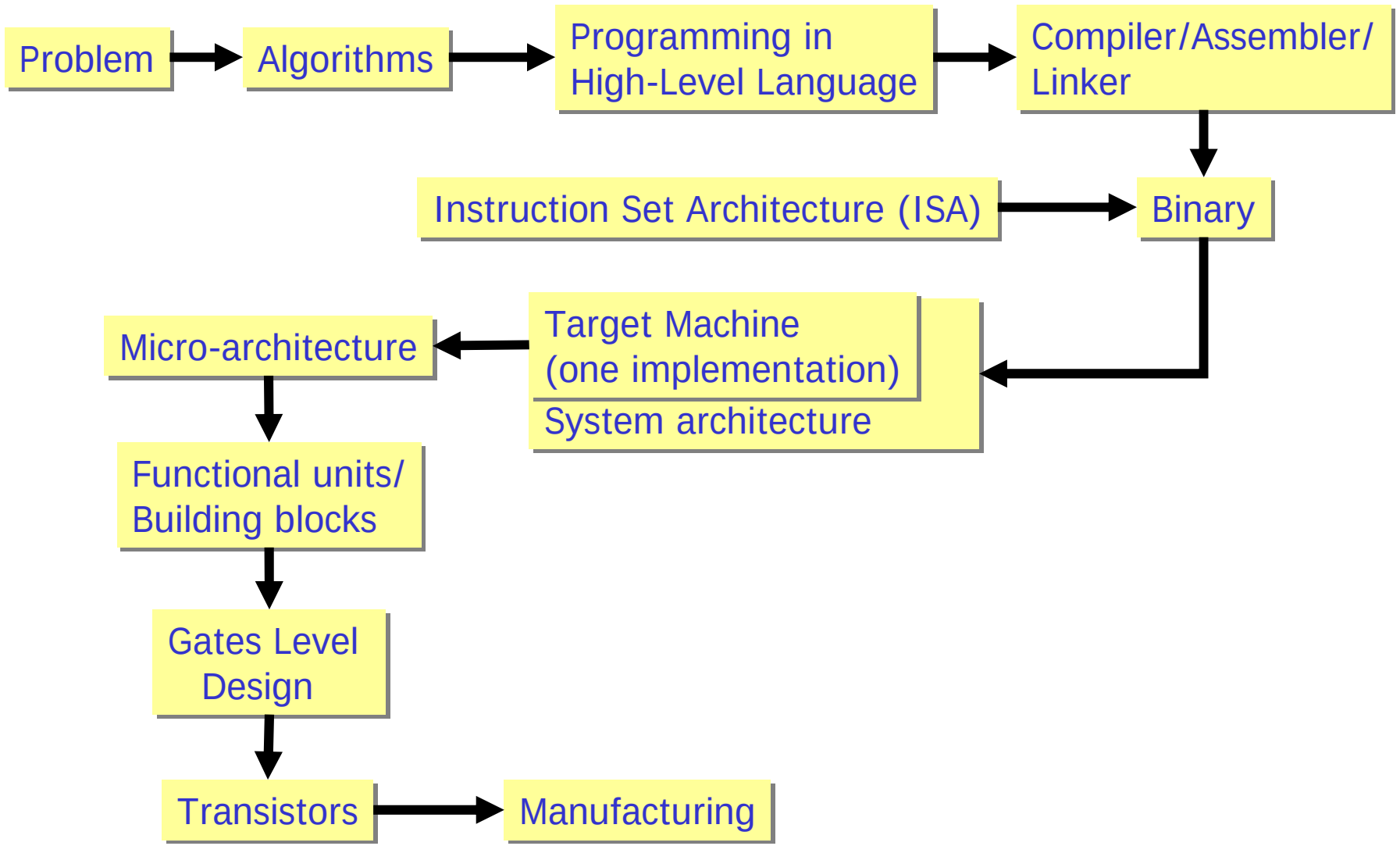
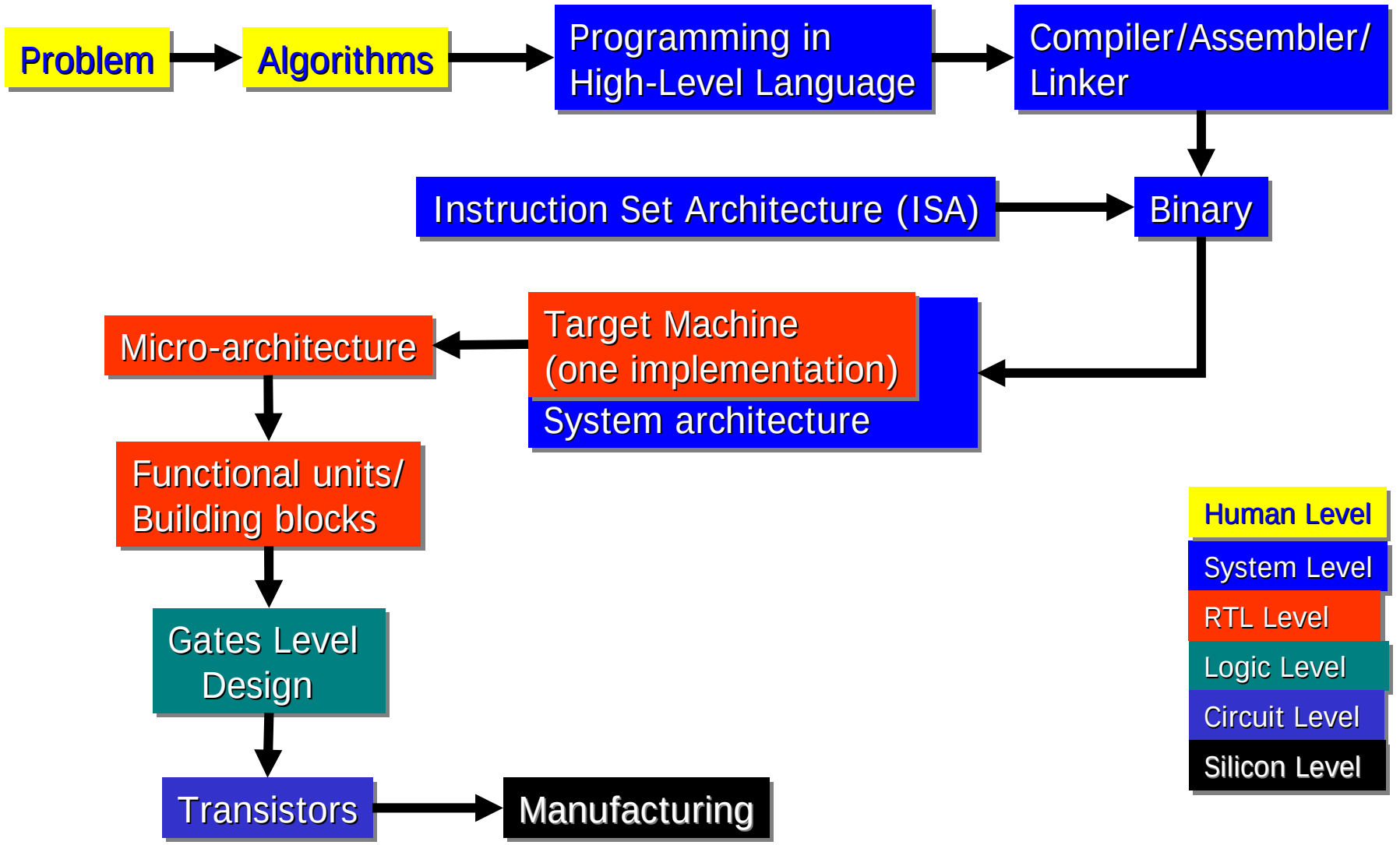
Intro

- Memory and Programmable Devices
  - Register, RAM, ROM, PLA, PAL
- Architectural concept
  - Instruction set architecture (ISA)
  - Stored-Program Computer and Sequential Control (von Neumann architecture)
  - Datapath
  - Branches
- Processor and Software Convention
  - MIPS ISA
  - Procedural calls: Stack

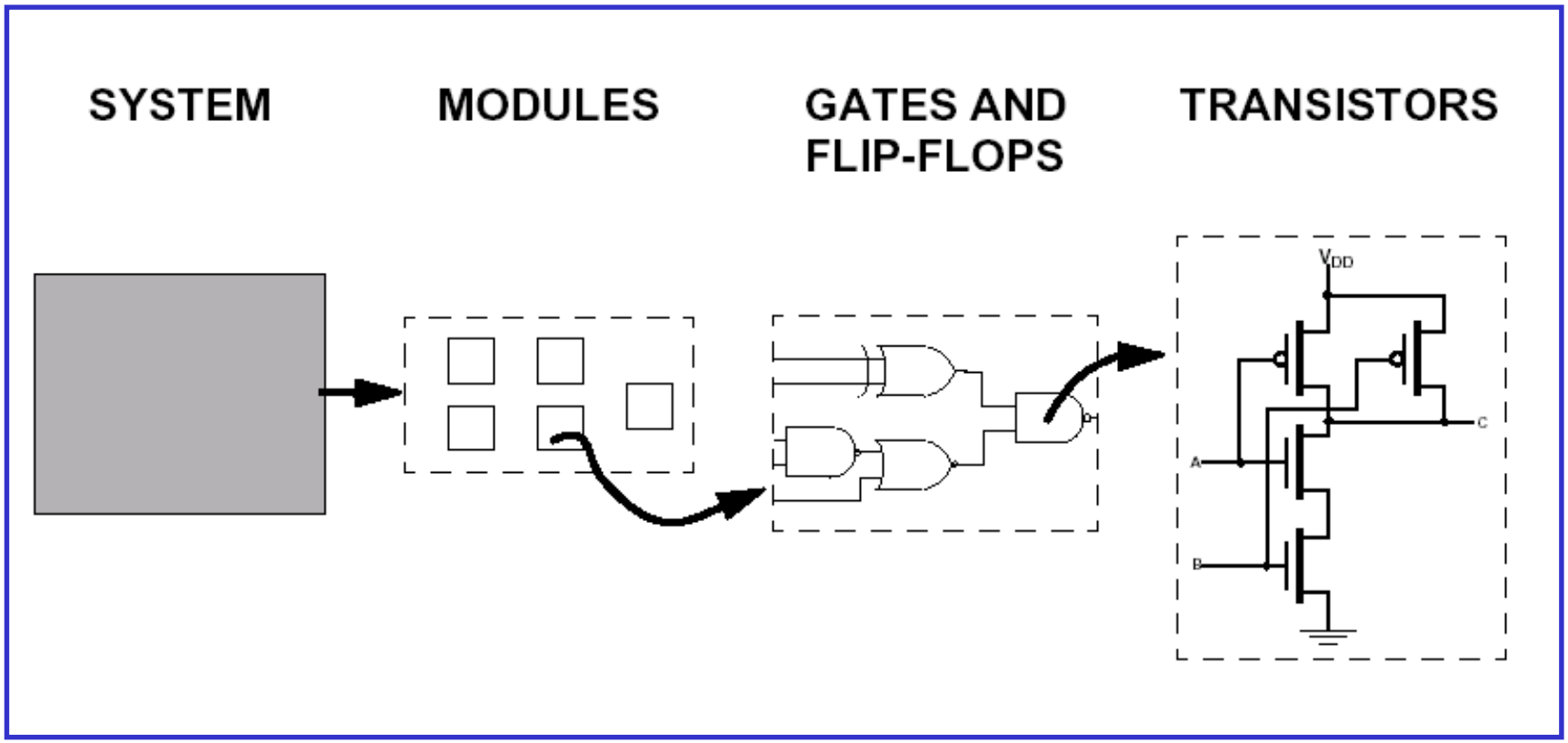
Hierarchy of Computation



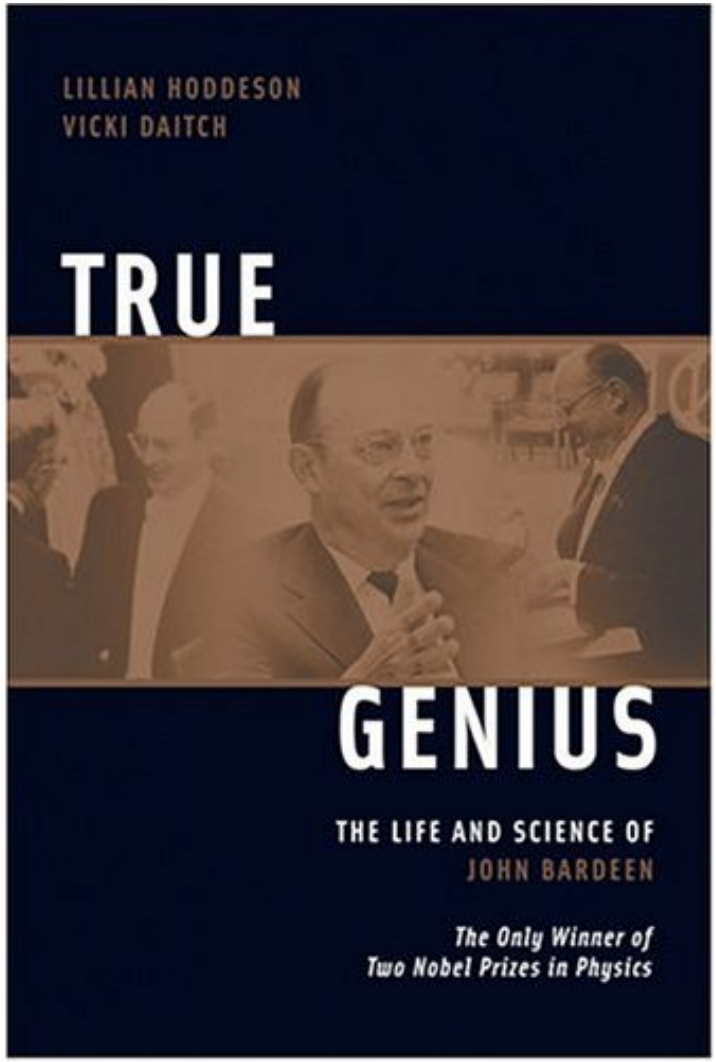
Hierarchy of Computation



Zooming into a System Component



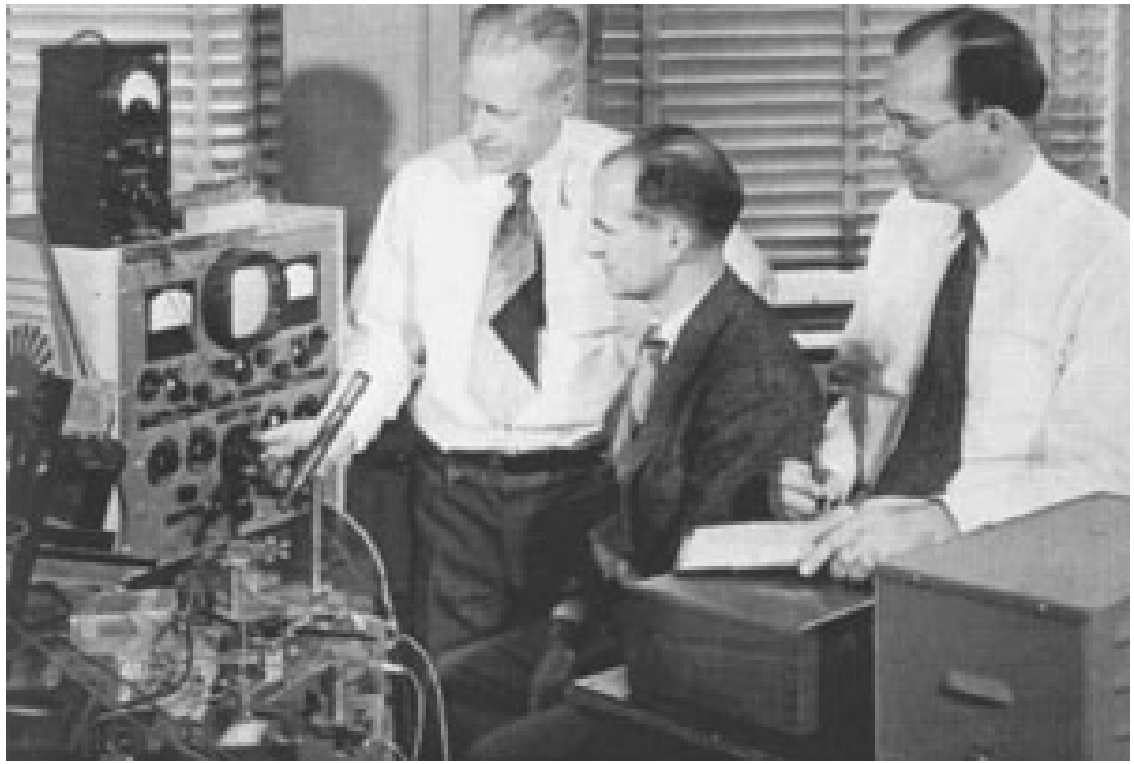
First Transistor



John Bardeen
William Shockley
Walter Brattain
Circa. 1947, Bell Labs

Nobel Prize in Physics 1956

First Transistor



John Bardeen
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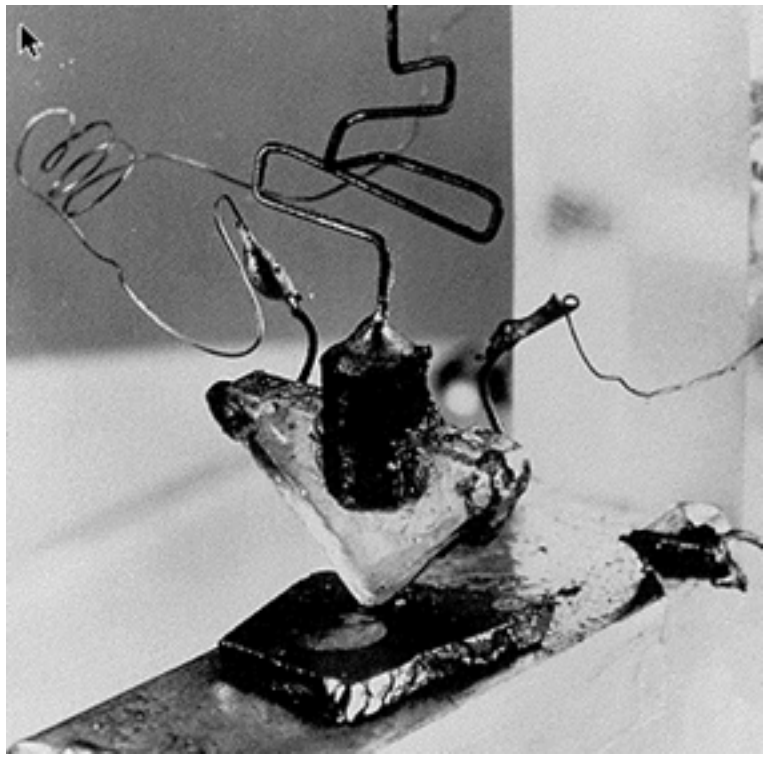
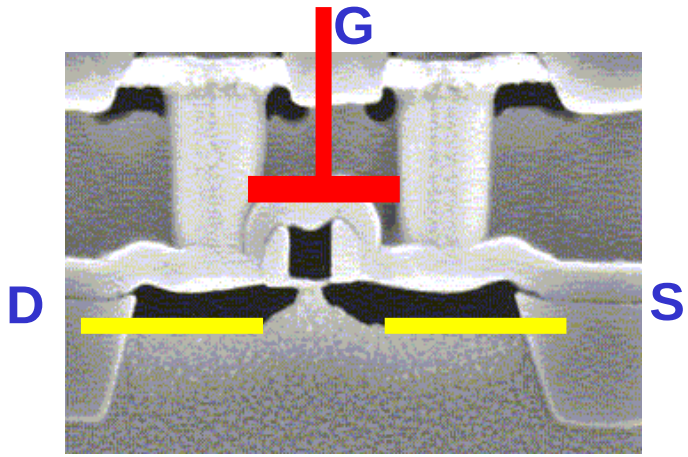
First Transistor



Switch



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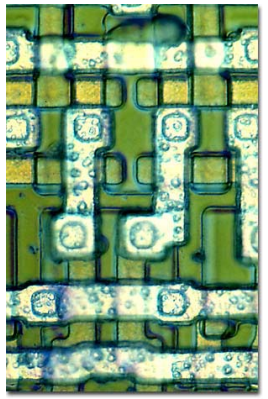
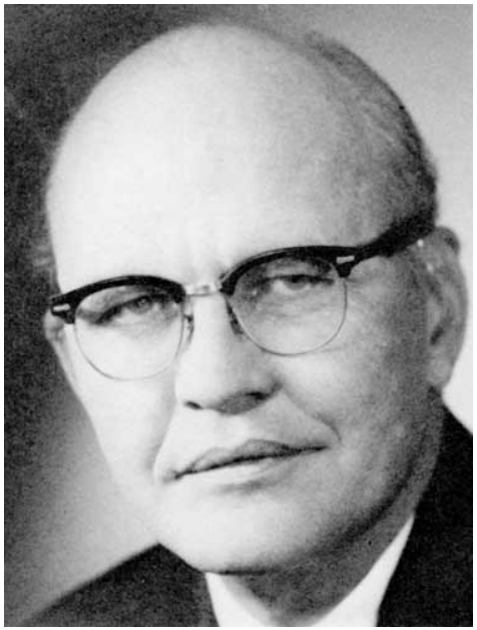
The inventors of the integrated circuit



Robert Noyce

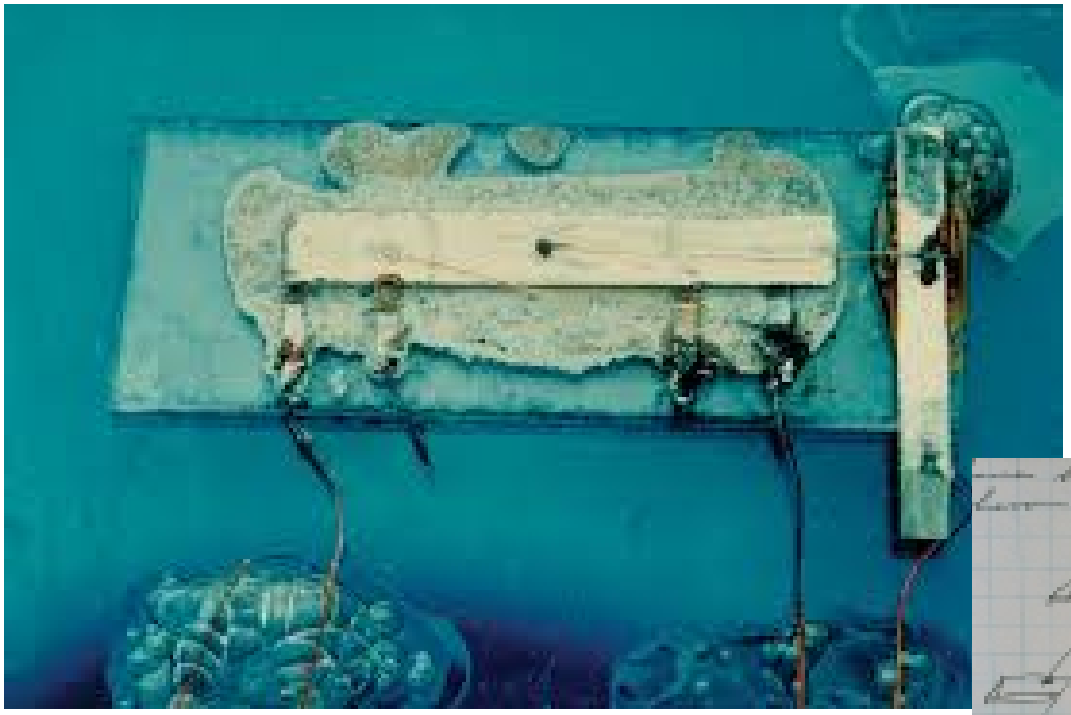


Jack Kilby
Nobel Prize in Physics 2000

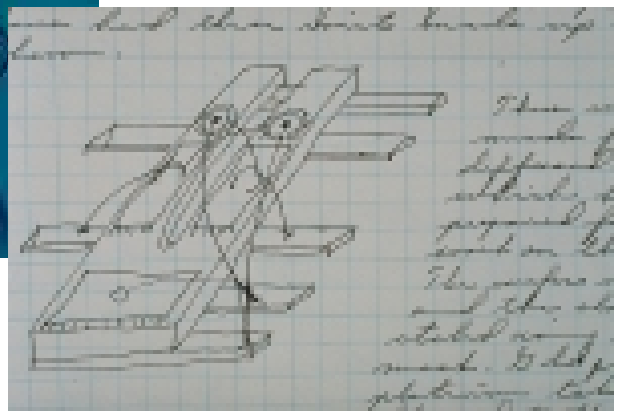
The inventors of the integrated circuit

Jack Kilby with first integrated circuit

The inventors of the integrated circuit



First integrated circuit
tested 12.09.1958



Jack Kilby first design
of an integrated circuit

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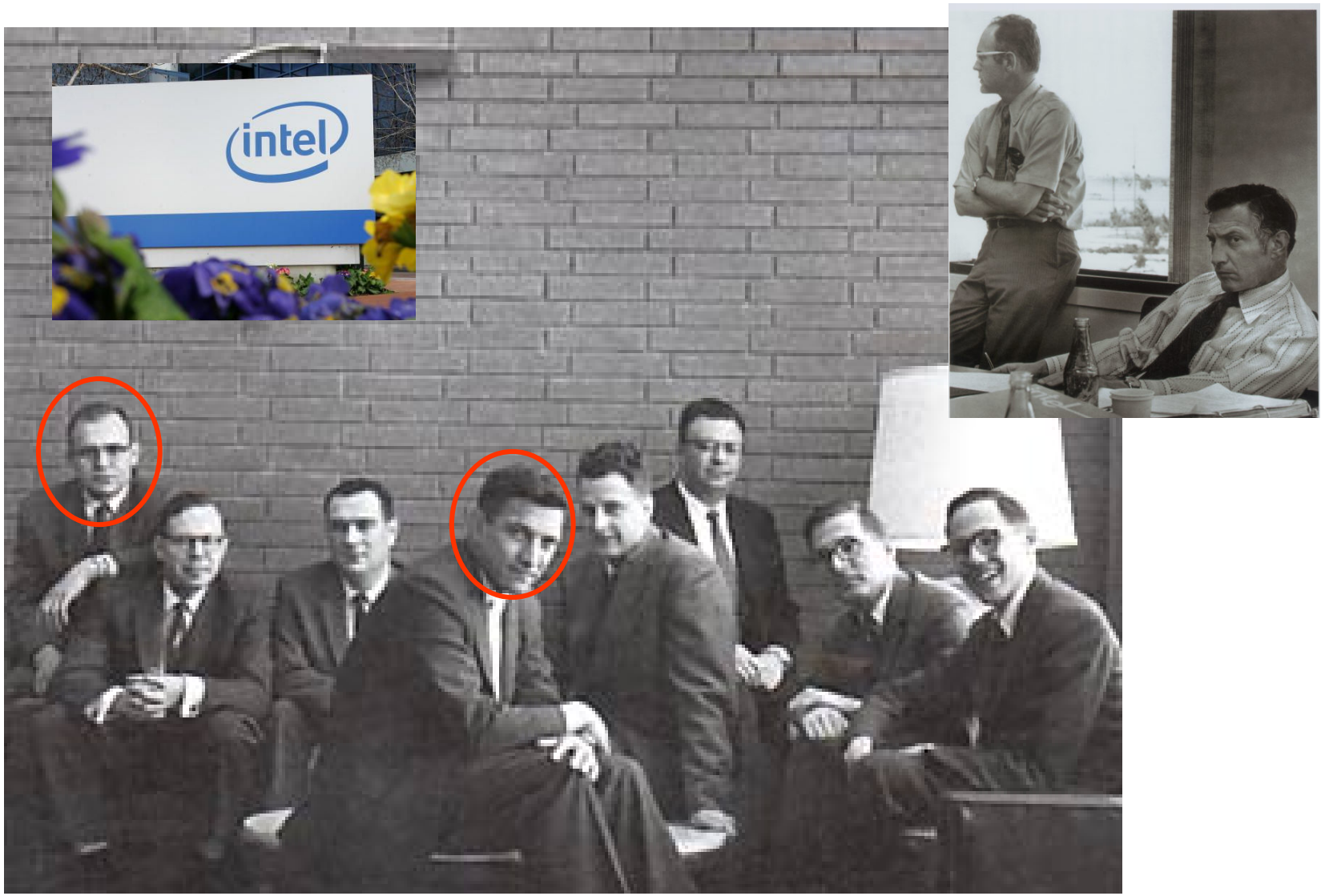
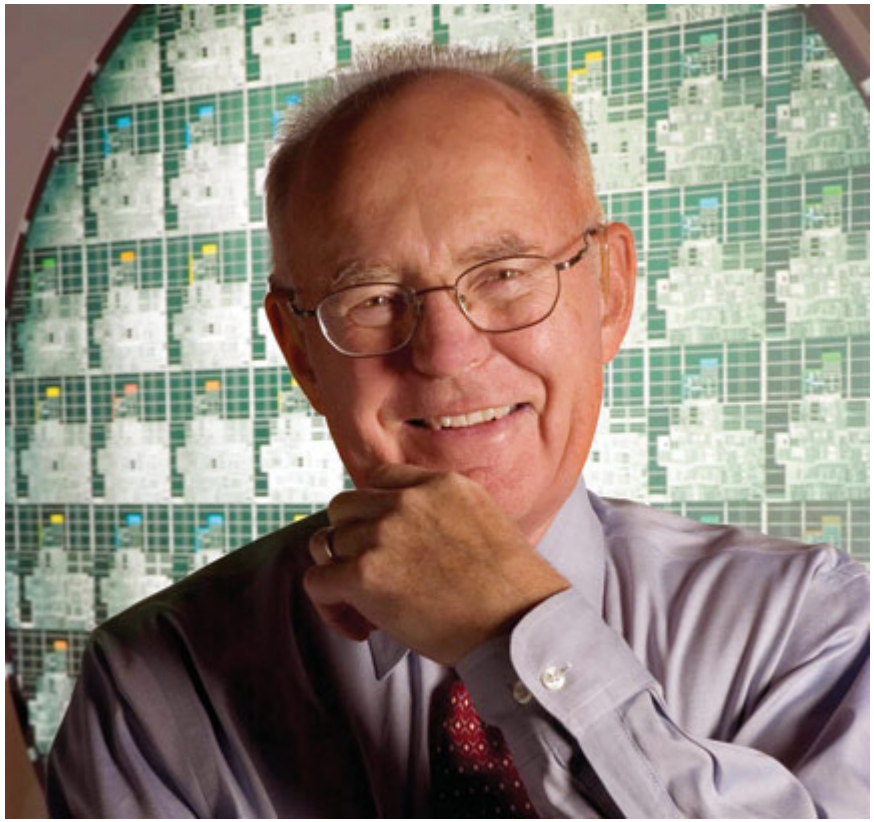
Fairchild



Fairchild



Gordon E. Moore circa. 1965

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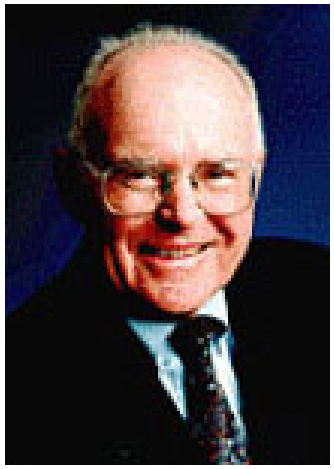
Moore's Law

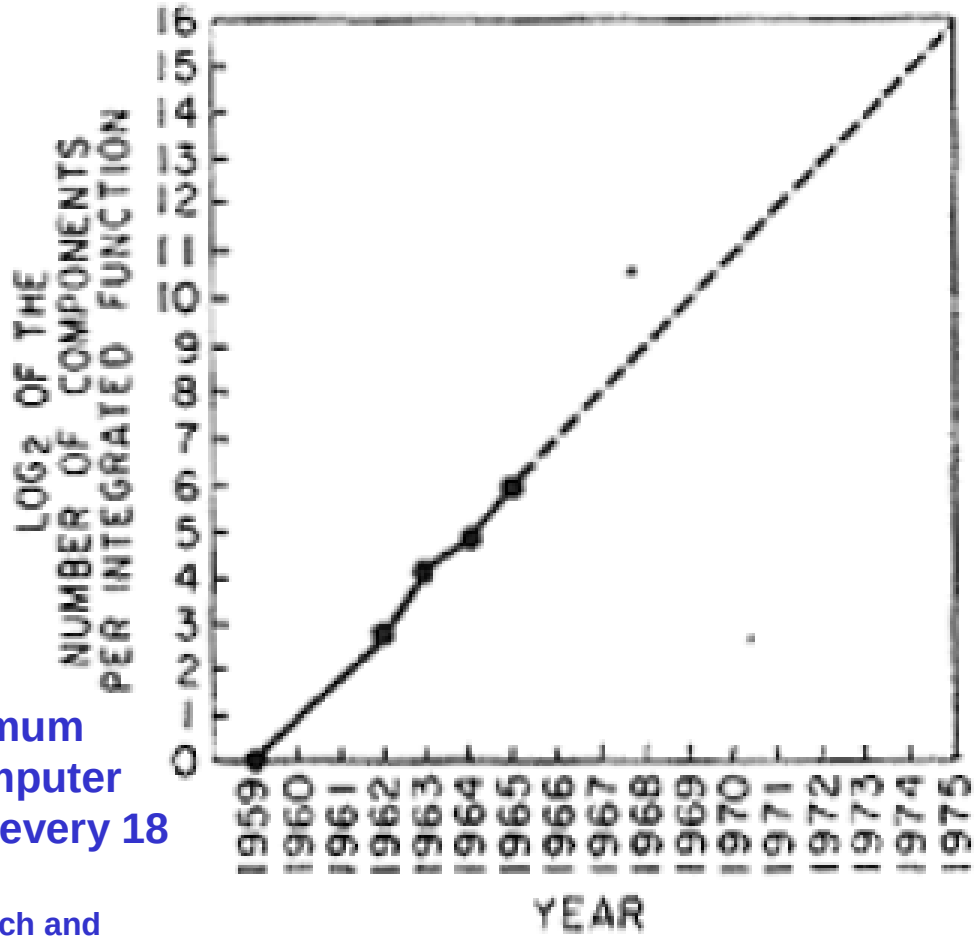


Gordon Moore

Co-founder of Intel in 1968.

Moore predicted that the maximum number of transistors on a computer chip would double every year (every 18 months).

In 1965 Moore was Director at the Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.



Ref.:
http://www.intel.com/research/silicon/mooreslaw.htm

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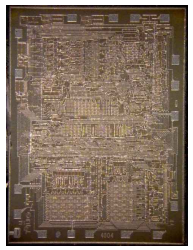
Moore's Law

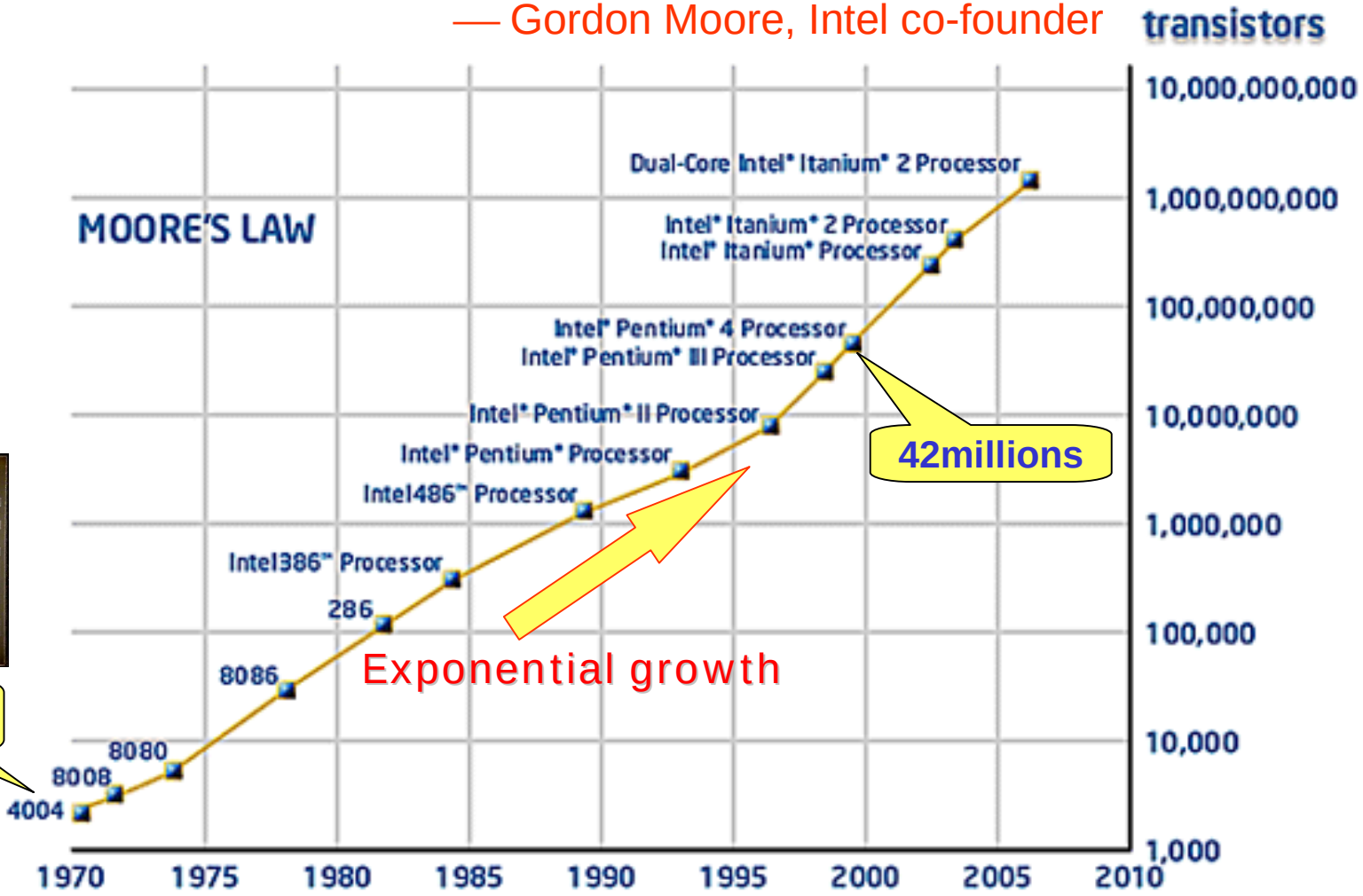
Transistor count will be doubled every 18 months

— Gordon Moore, Intel co-founder



10 μm
13.5mm²

2,250



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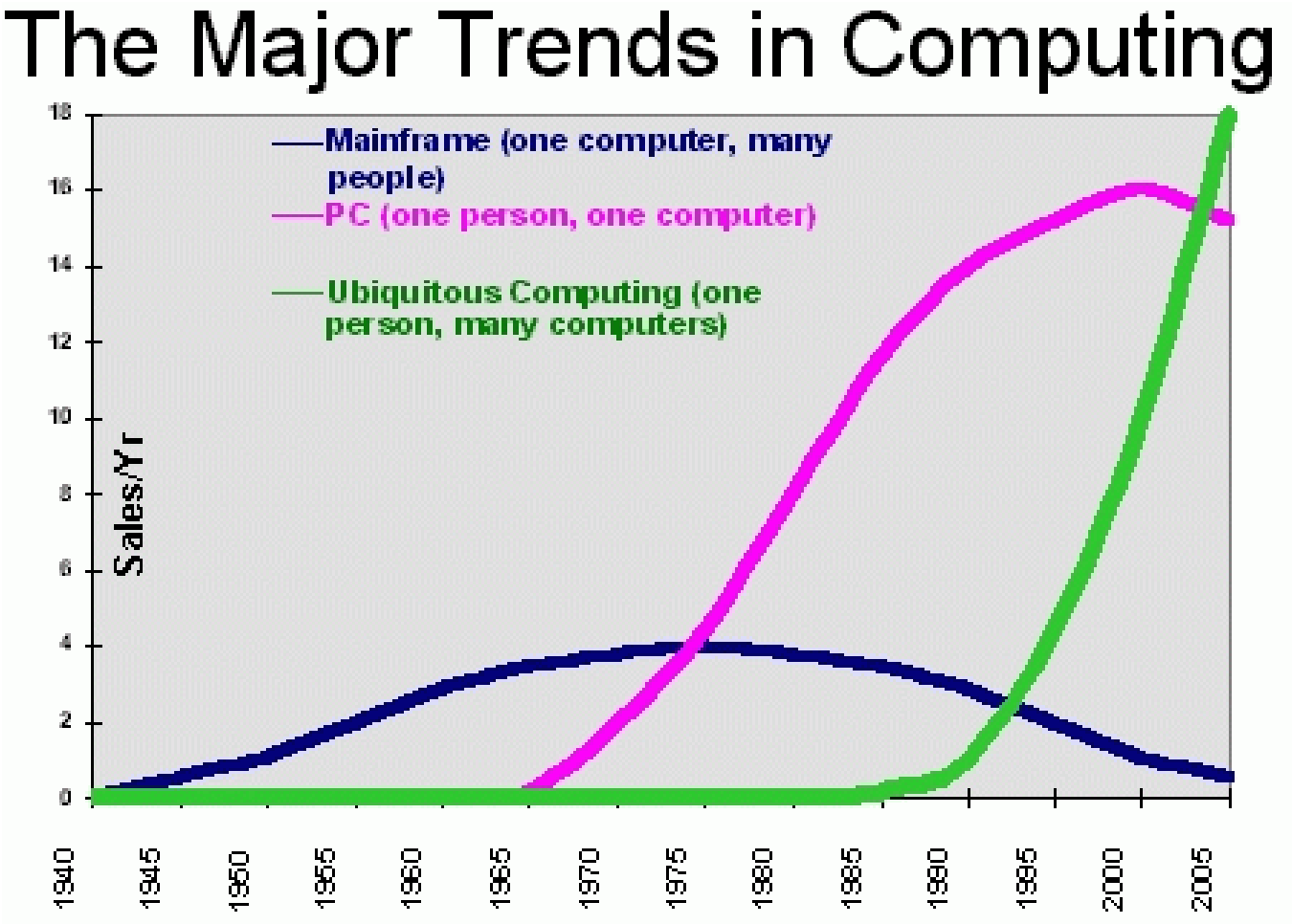
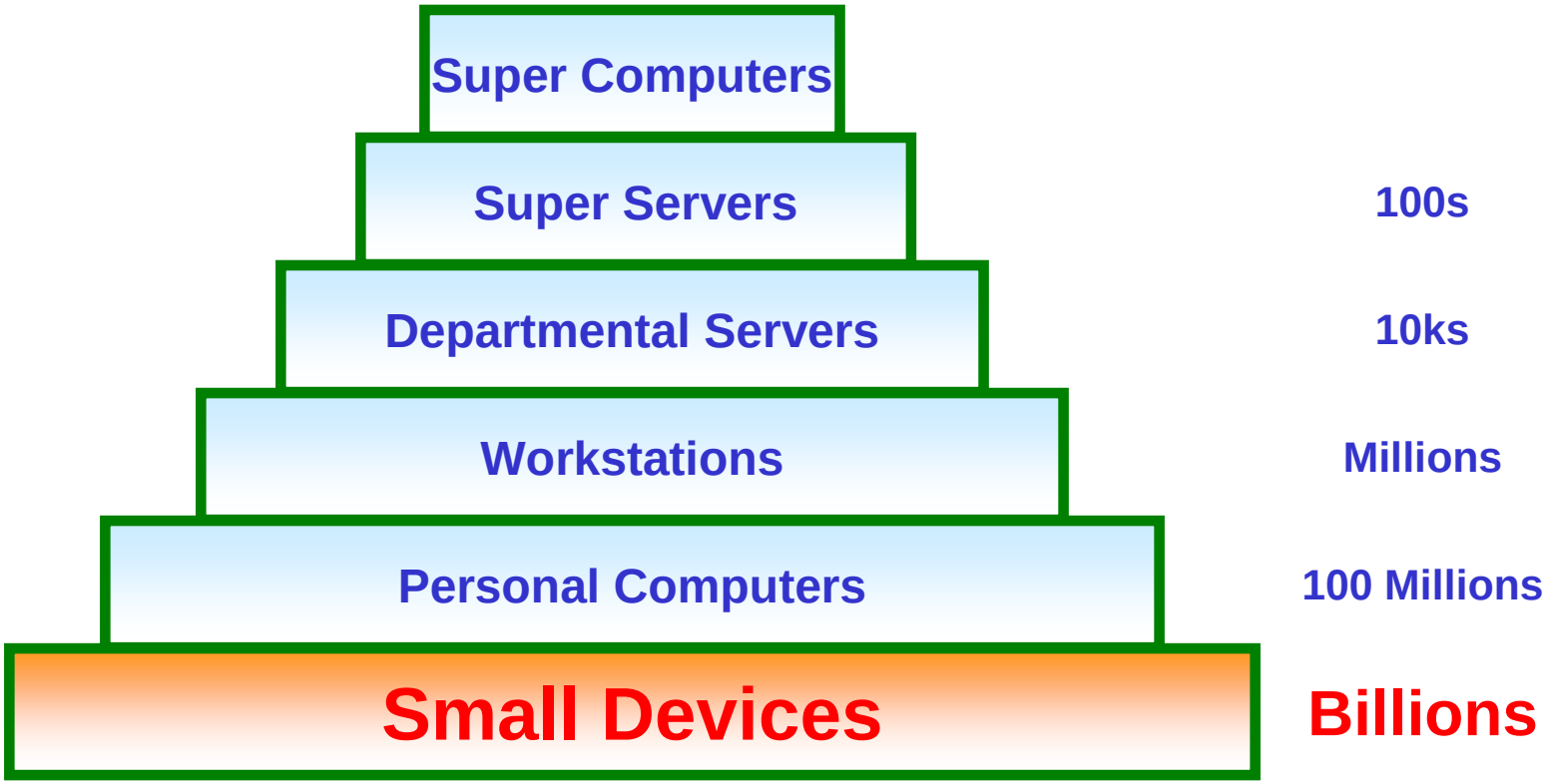
Trends in Computing

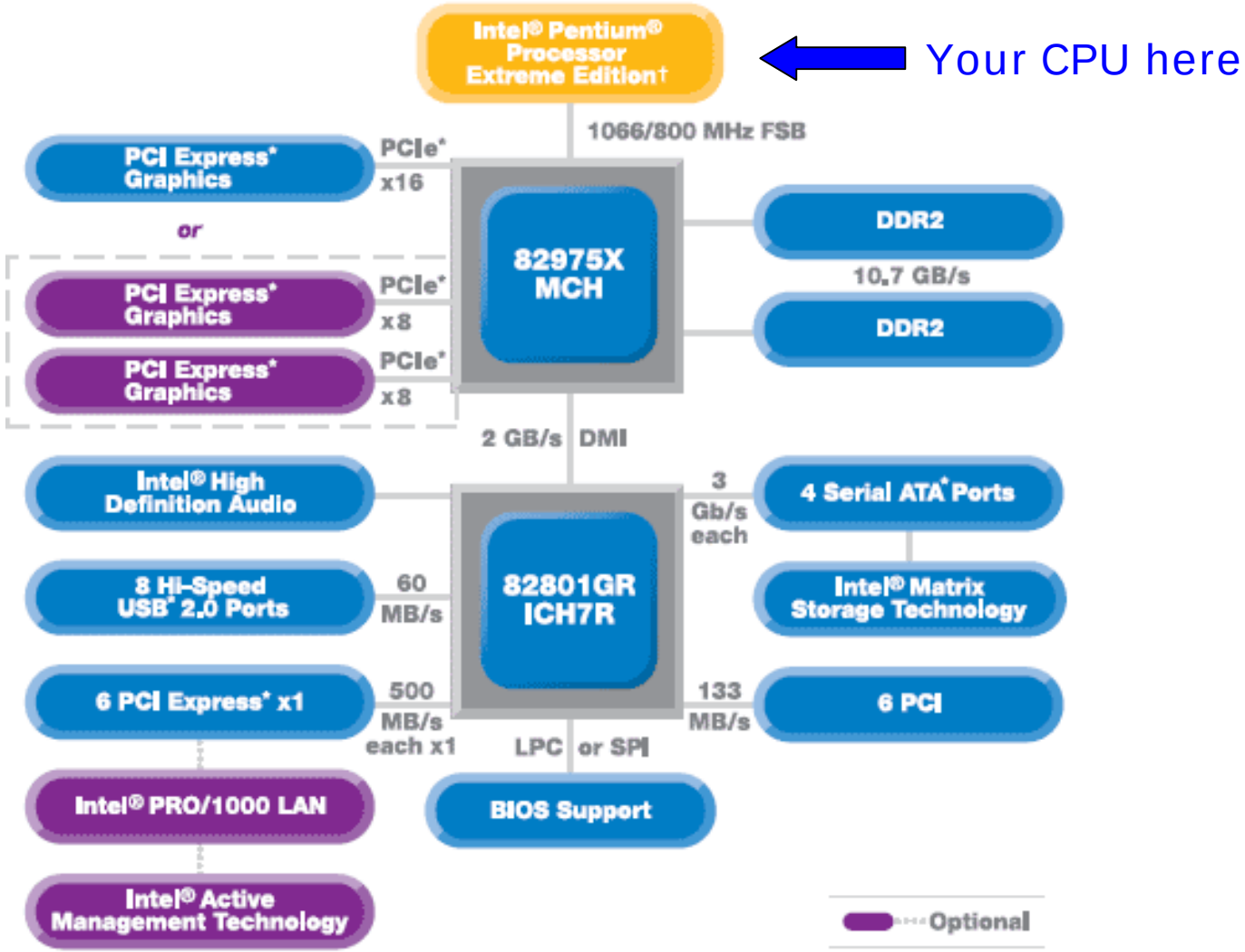


Emerging Platform Pyramid

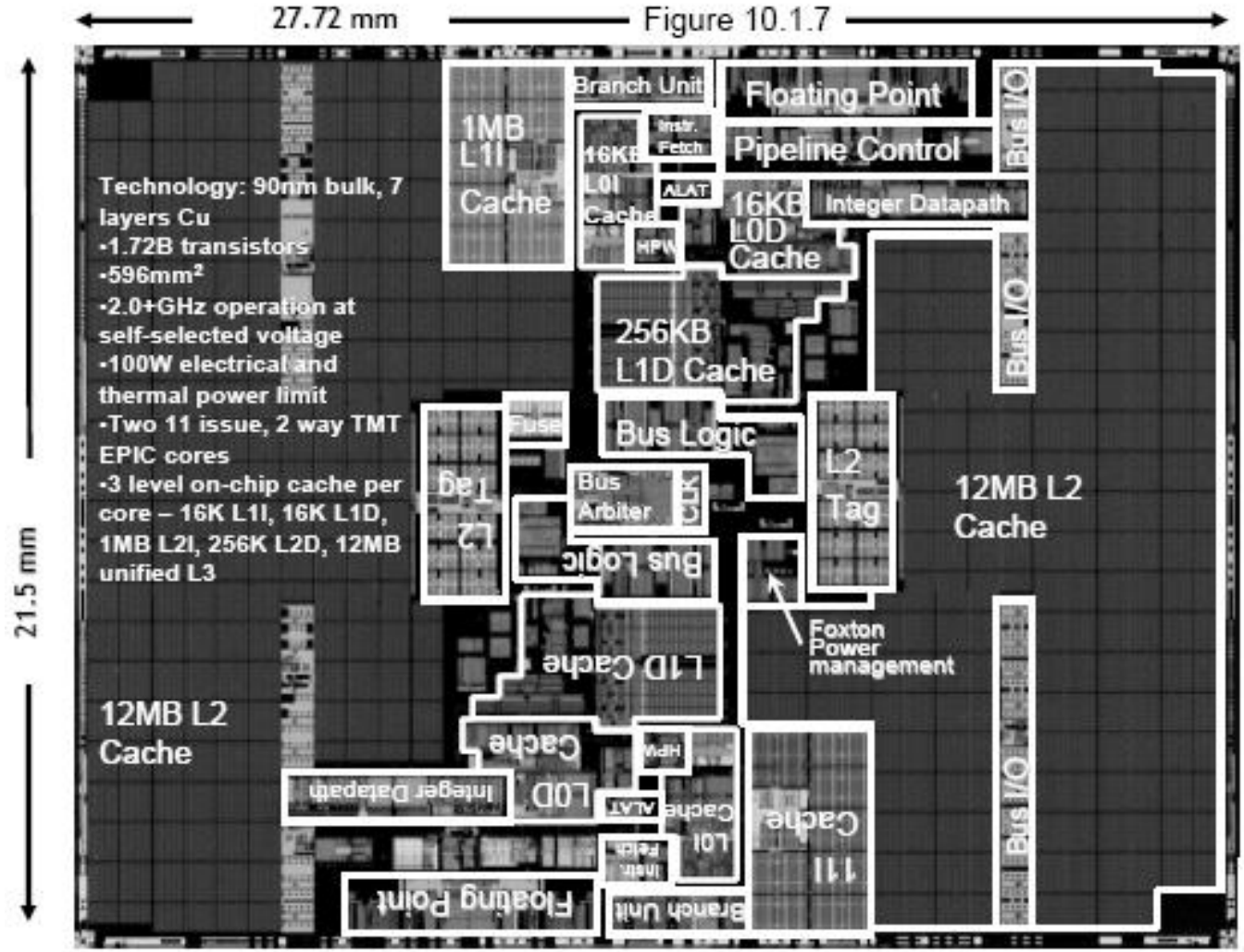


David Culler, U.C. Berkeley
ISRG Retreat

A Generic Intel-based PC System



Dual-Core Itanium 2 (Montecito)



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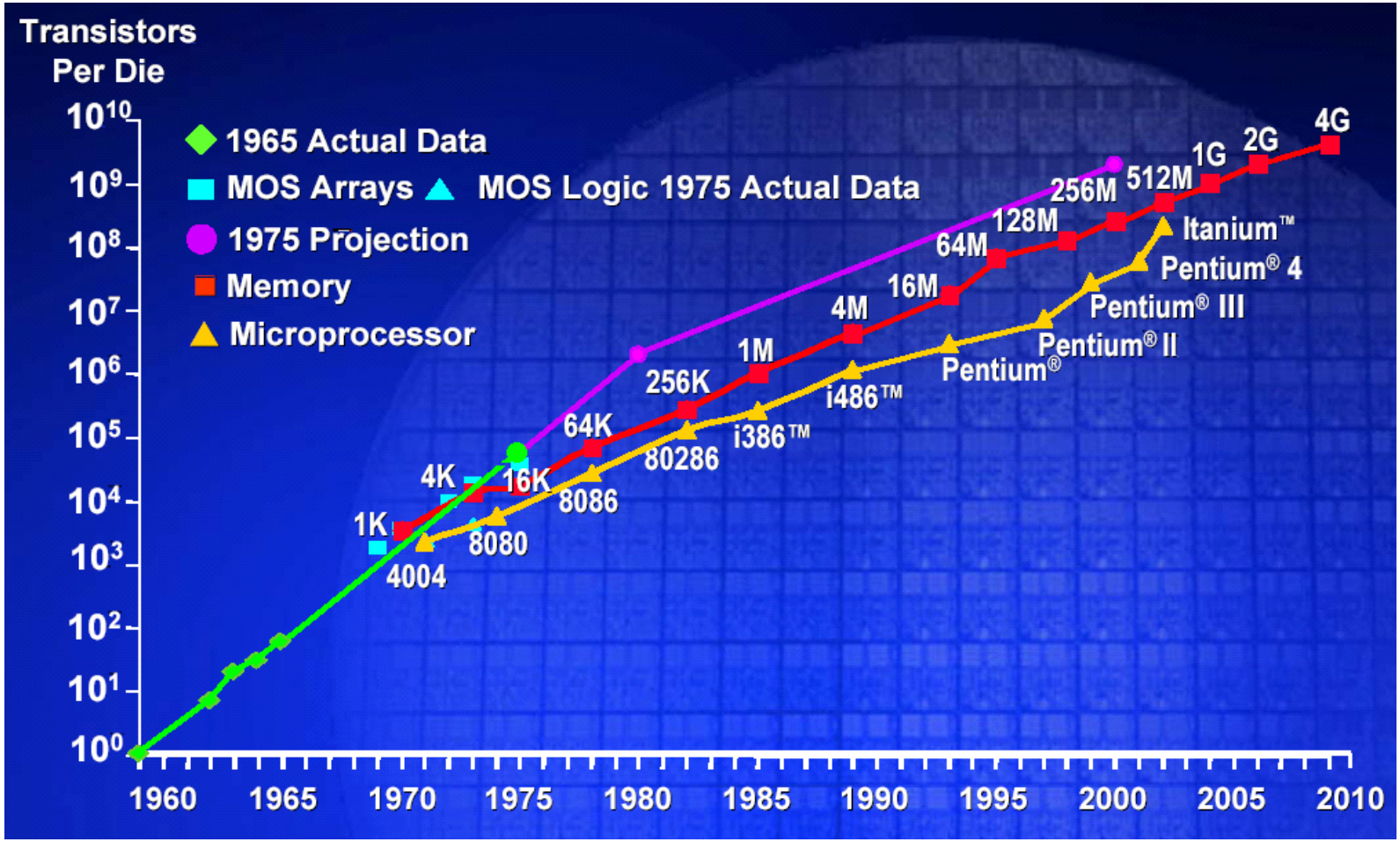
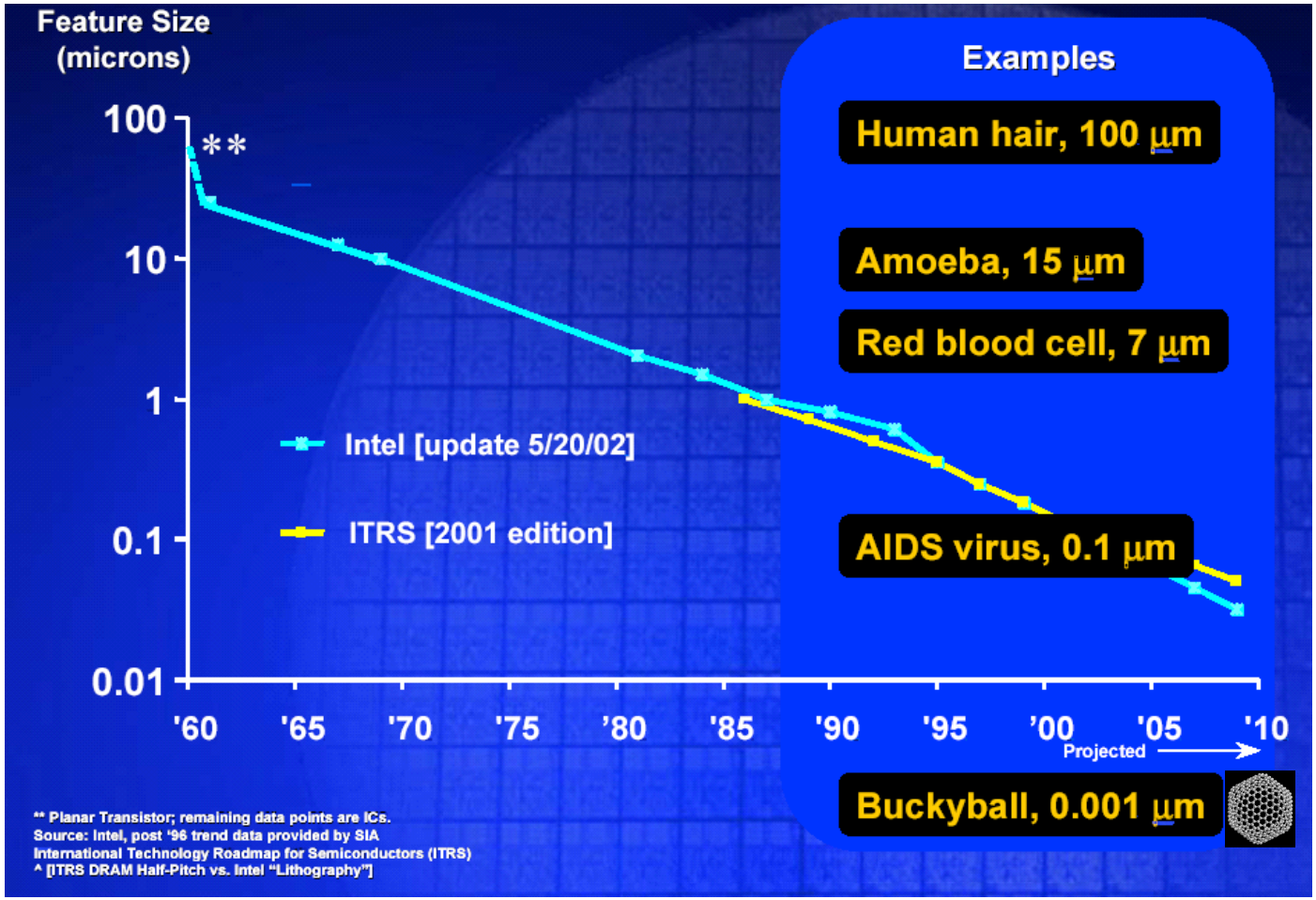
Integrated Circuit Complexity



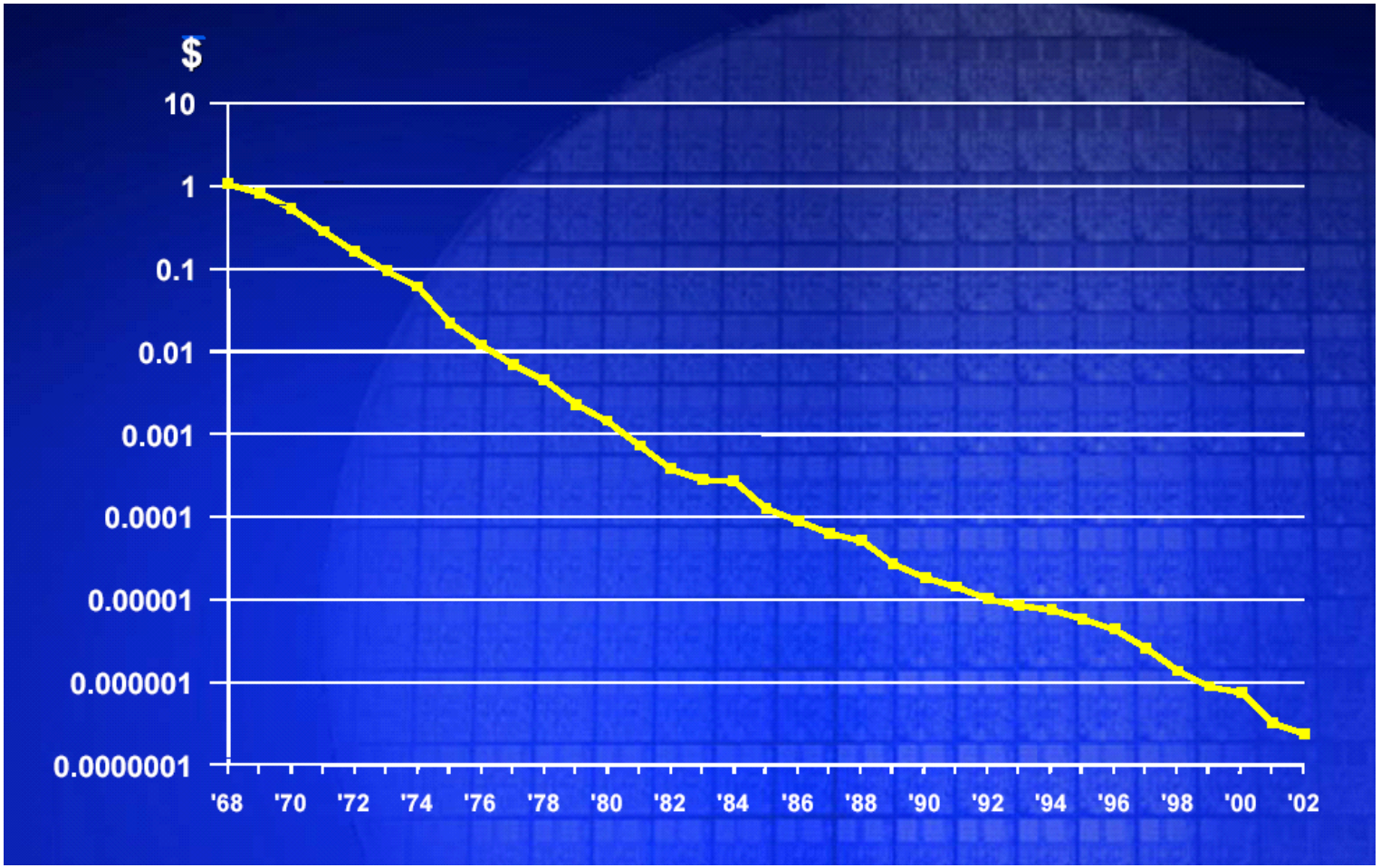
Source: Intel

Minimum Feature Size



We are currently at 0.065µm (65nm) and moving towards 0.045µm

Average Transistor Price



Source: Dataquest

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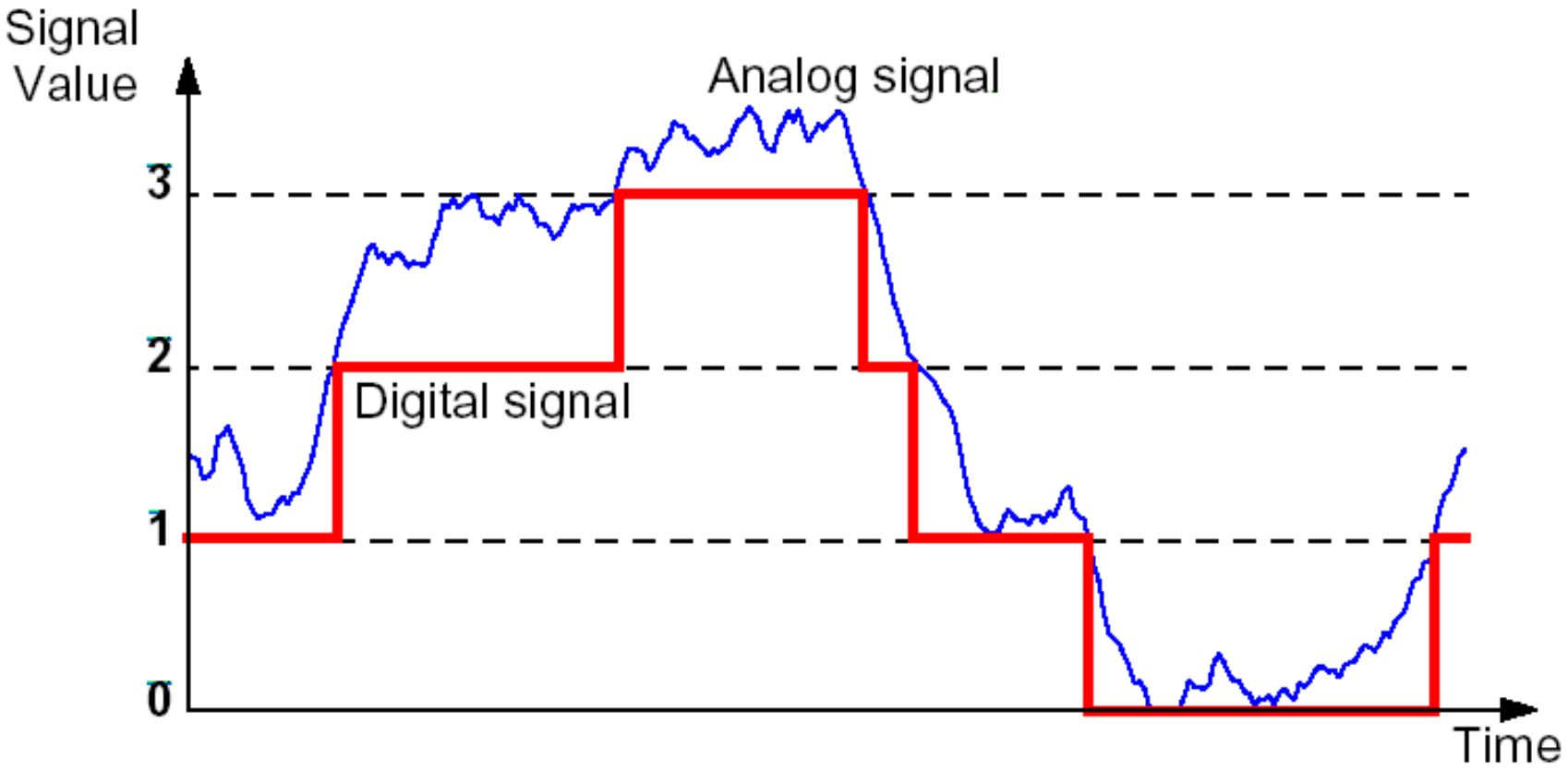
Processor Market Segmentation

High Performance
(e.g., Intel 32/64, AMD, Itanium, IBM POWER, BlueGene, Sun T1, etc)

Embedded / low-power
(e.g., ARM, MIPS, Xscale)

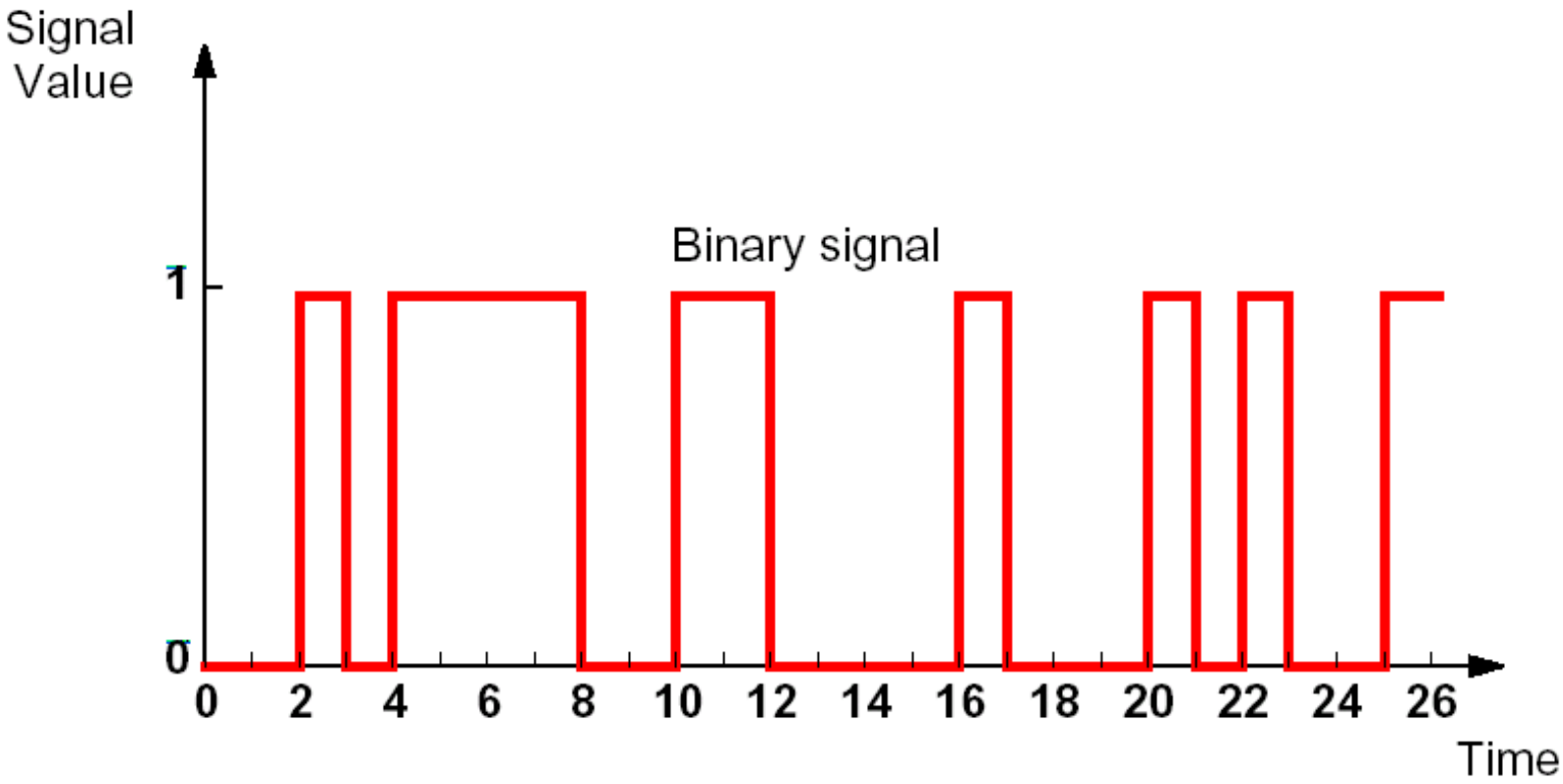
Special purpose
(e.g., DSP, NVidia)

Analog versus Digital Signal



Why Digital?

Binary Signals



Why Binary?

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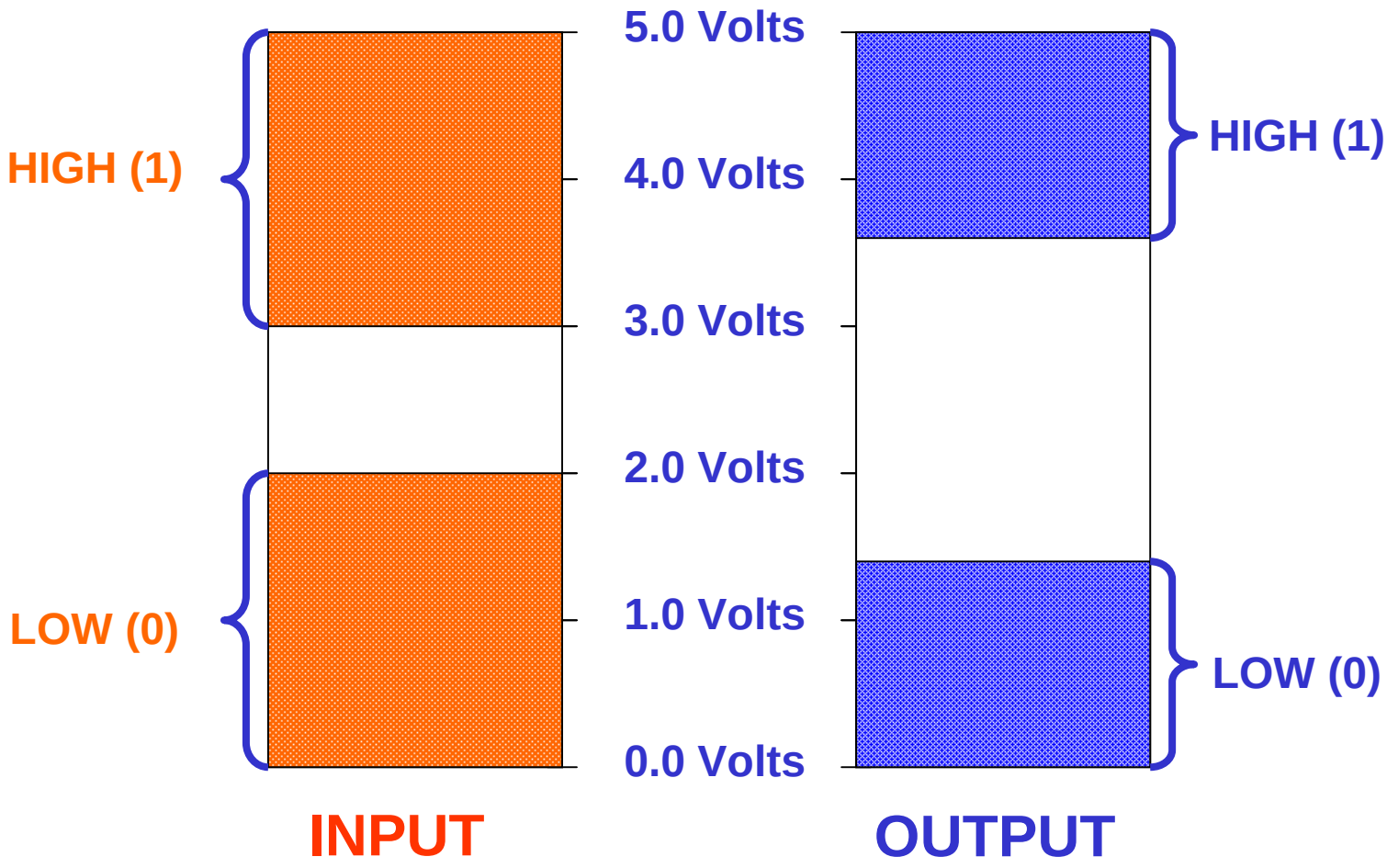
Voltage Range of Binary Signals



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End

Thank you!