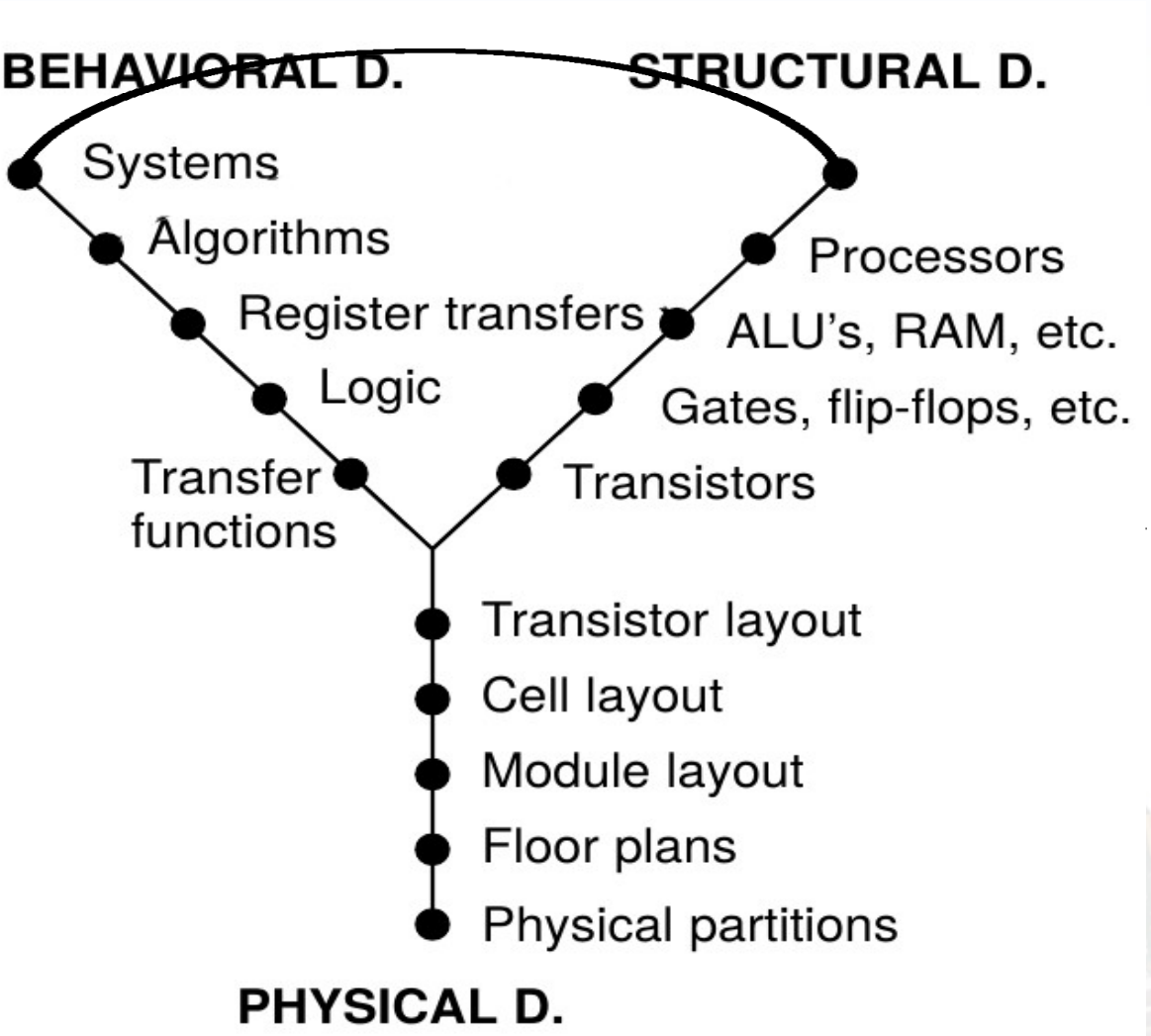
Tassadaq Hussain

VLSI Design

System-on-Chip (SoC) and use of VLSI circuit design technology

System on Chip Design

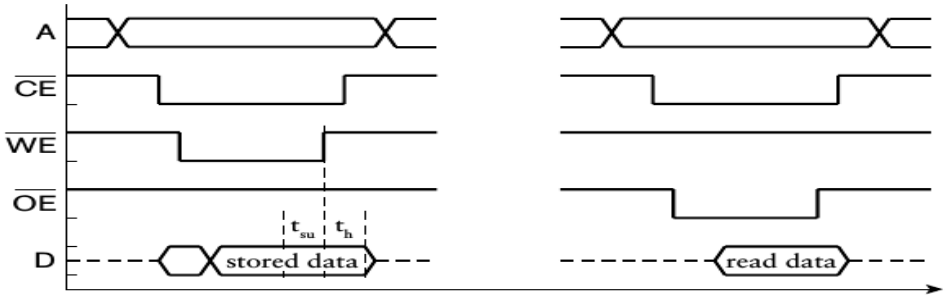


Agenda

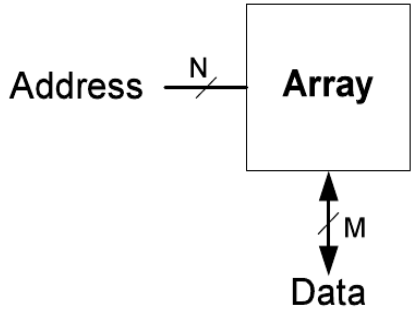
- Introduction .
- What is SoC ?
- SoC characteristics .
- Benefits and drawbacks .
- Solution .
- Major SoC Applications .
- Summary .

Design SRAM Memory having 32 bit data width and depth of your CMS Number

```
module sram (
address     , // Address Input
data        , // Data bi-directional
cs          , // Chip Select
we          , // Write Enable/Read Enable
oe          // Output Enable
);
//-------------Input Ports----------------------
input [ADDR_WIDTH-1:0] address ;
input                  cs      ;
input                  we      ;
input                  oe      ;
//-------------Inout Ports----------------------
inout [DATA_WIDTH-1:0]  data      ;
//-------------Internal variables---------------
reg [DATA_WIDTH-1:0]   data_out ;
Reg mem ;
//-------------Code Starts Here-----------------
assign data = (cs && oe && !we) ? data_out : 8'bz;
```




```
// Memory Write Block
always @ (xxxxx)
begin : MEM_WRITE
   If ( xxxx ) begin
       mem = data;
   end end
// Memory Read Block
always @ (xxxxx)
begin : MEM_READ
    if (xxxxx)  begin
        data_out = mem;
   end end
endmodule
```



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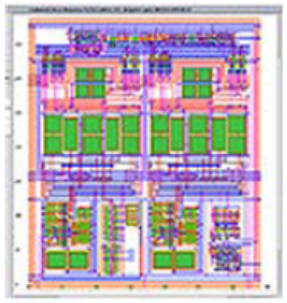
Introduction

- Technological Advances
  - today's chip can contains 100M transistors .
  - transistor gate lengths are now in term of nano meters .
  - approximately every 18 months the number of transistors on a chip doubles – Moore's law .
- The Consequences
  - components connected on a Printed Circuit Board can now be integrated onto single chip .
  - hence the development of System-On-Chip design .

From PCB to SoC



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What is SoC ?

The VLSI manufacturing technology advances has made possible to put millions of transistors on a single die. It enables designers to put systems-on-a-chip that move everything from the board onto the chip eventually.

A system on a chip or system on chip (SoC or SOC) is an integrated circuit (IC) that integrates all components of a computer or other electronic system into a single chip. It may contain digital, analog, mixed-signal, and often radio-frequency functions—all on a single chip substrate. SoCs are very common in the mobile electronics market because of their low power consumption. A typical application is in the area of embedded systems.

SoC is a high performance microprocessor, since we can program and give instruction to the uP to do whatever you want to do.

SoC is the efforts to integrate heterogeneous or different types of silicon IPs (hardwares) on to the same chip, like memory, uP, random logics, and analog circuitry.

All of the above are partially right, but not very accurate!!!

What is SoC ?

SoC not only chip, but more on “system”.

SoC = Chip + Software + Integration

The SoC chip includes:

Embedded processor

ASIC Logics and analog circuitry

Embedded memory

The SoC Software includes:

OS, compiler, simulator, firmware, driver, protocol stackIntegrated development environment (debugger, linker, ICE)Application interface (C/C++, assembly)

The SoC Integration includes :

The whole system solution

Manufacture consultant

Technical Supporting

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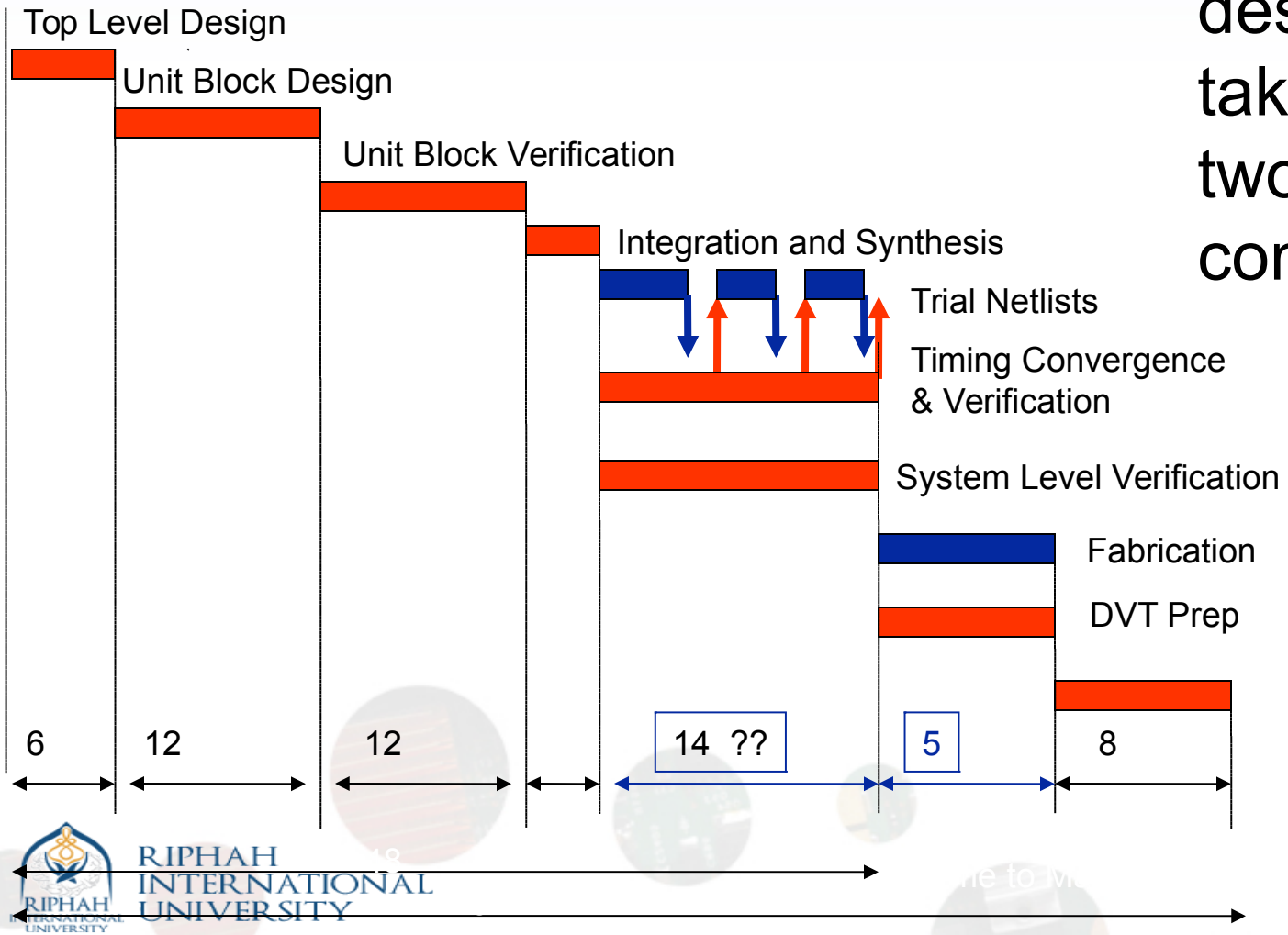
System on Chip architecture

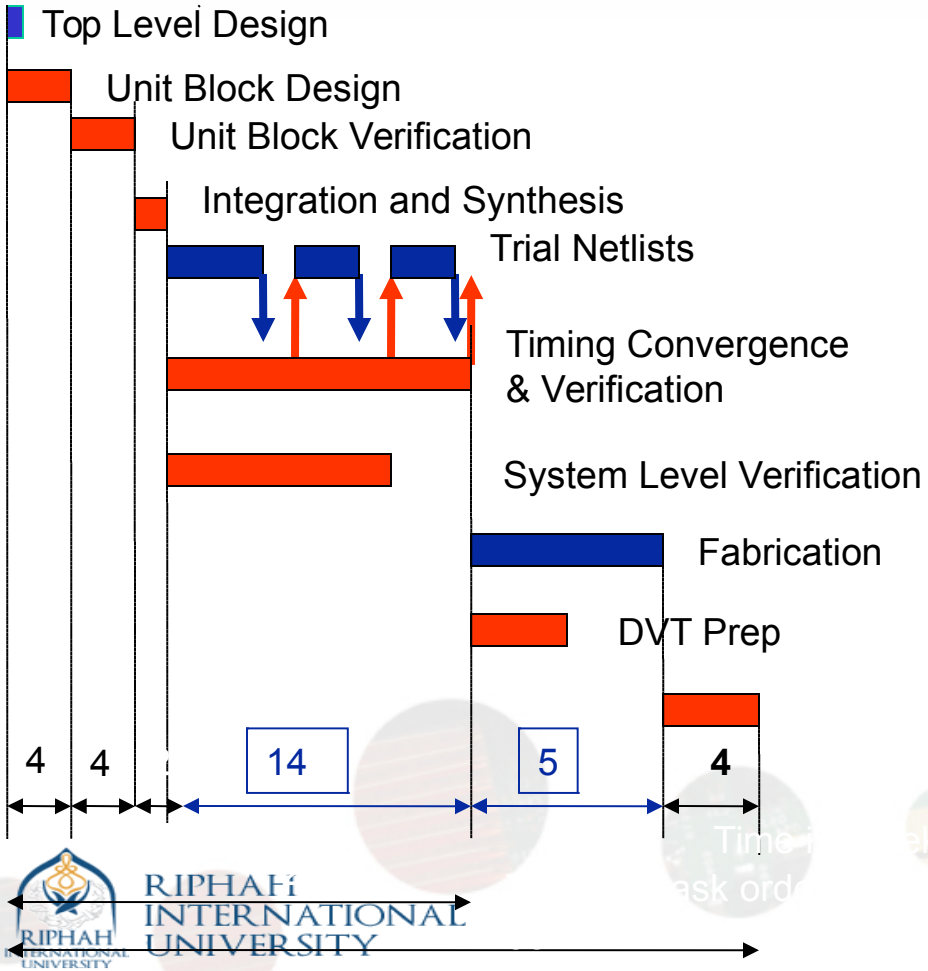
ASIC Typical Design Steps



- Typical ASIC design can take up to two years to complete

System on Chip architecture

SoC Typical Design Steps



- With increasing Complexity of IC's and decreasing Geometry, IC Vendor steps of Placement, Layout and Fabrication are unlikely to be greatly reduced

- In fact there is a greater risk that Timing Convergence steps will involve more iteration.

- Need to reduce time before Vendor Steps.

- Need to consider Layout issues up-front.

System on Chip interconnection

- Design reuse is facilitated if “standard” internal connection buses are used .
- All cores connect to the bus via a standard interface .
- Any-to-any connections easy but …
  - Not all connections are necessary .
  - Global clocking scheme .
  - Power consumption .
- Standardization is being addressed by the Virtual Socket Interface Alliance (VSIA)

System on Chip interconnection

- **AMBA** (Advanced Microcontroller Bus Architecture) is a collection of buses from ARM for satisfying a range of different criteria.
- **APB** (Advanced Peripheral Bus): simple strobed-access bus with minimal interface complexity. Suitable for hosting peripherals.
- **ASB** (Advanced System Bus): a multimaster synchronous system bus.
- **AHB** (Advanced High Performance Bus): a high-throughput synchronous system backbone. Burst transfers and split transactions.

Types of Bus Architectures

- Single Layer
- Multi Layer
- Network on Chip
- Pattern Based Bus Architecture

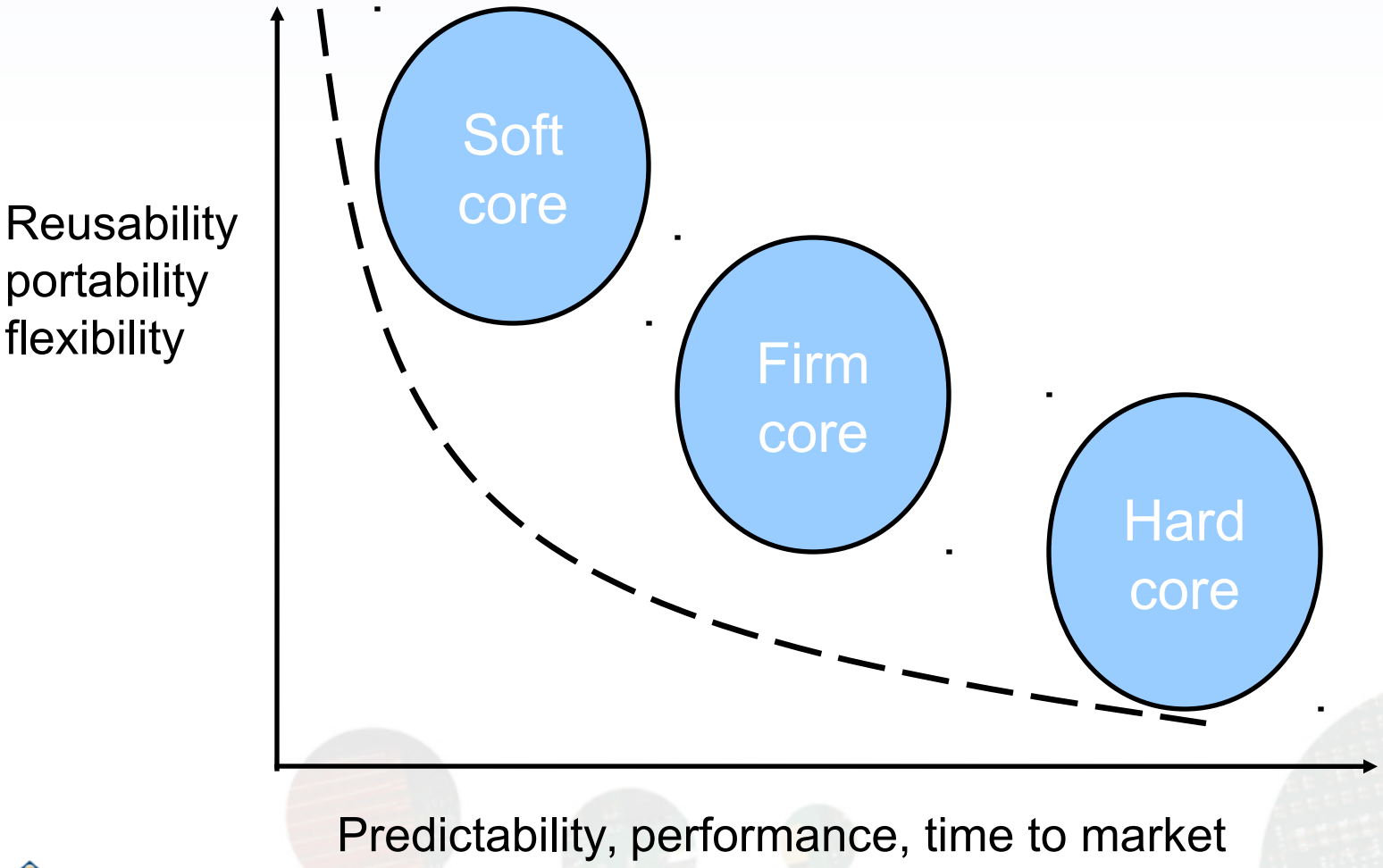
System on Chip cores

- One solution to the design productivity gap is to make ASIC designs more standardized by reusing segments of previously manufactured chips.
- These segments are known as “blocks”, “macros”, “cores” or “cells”.
- The blocks can either be developed in-house or licensed from an IP company.
- Cores are the basic building blocks .

System on Chip cores

- **Soft Macro**
  - Reusable synthesizable RTL or netlist of generic library elements
  - User of the core is responsible for the implementation and layout
- **Firm Macro**
  - Structurally and topologically optimized for performance and area through floor planning and placement
  - Exist as synthesized code or as a netlist of generic library elements
- **Hard Macro**
  - Reusable blocks optimized for performance, power, size and mapped to a specific process technology
  - Exist as fully placed and routed netlist and as a fixed layout such as in GDSII format .

System on Chip cores



System on Chip cores

- Locating the required cores and associated contract discussions can be a lengthy process
  - Identification of IP vendors
  - Evaluation criteria
  - Comparative evaluation exercise
  - Choice of core
  - Contract negotiations
    - Reuse restrictions
    - Costs: license, royalty, tool costs
  - Core integration, simulation and verification

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The Benefits

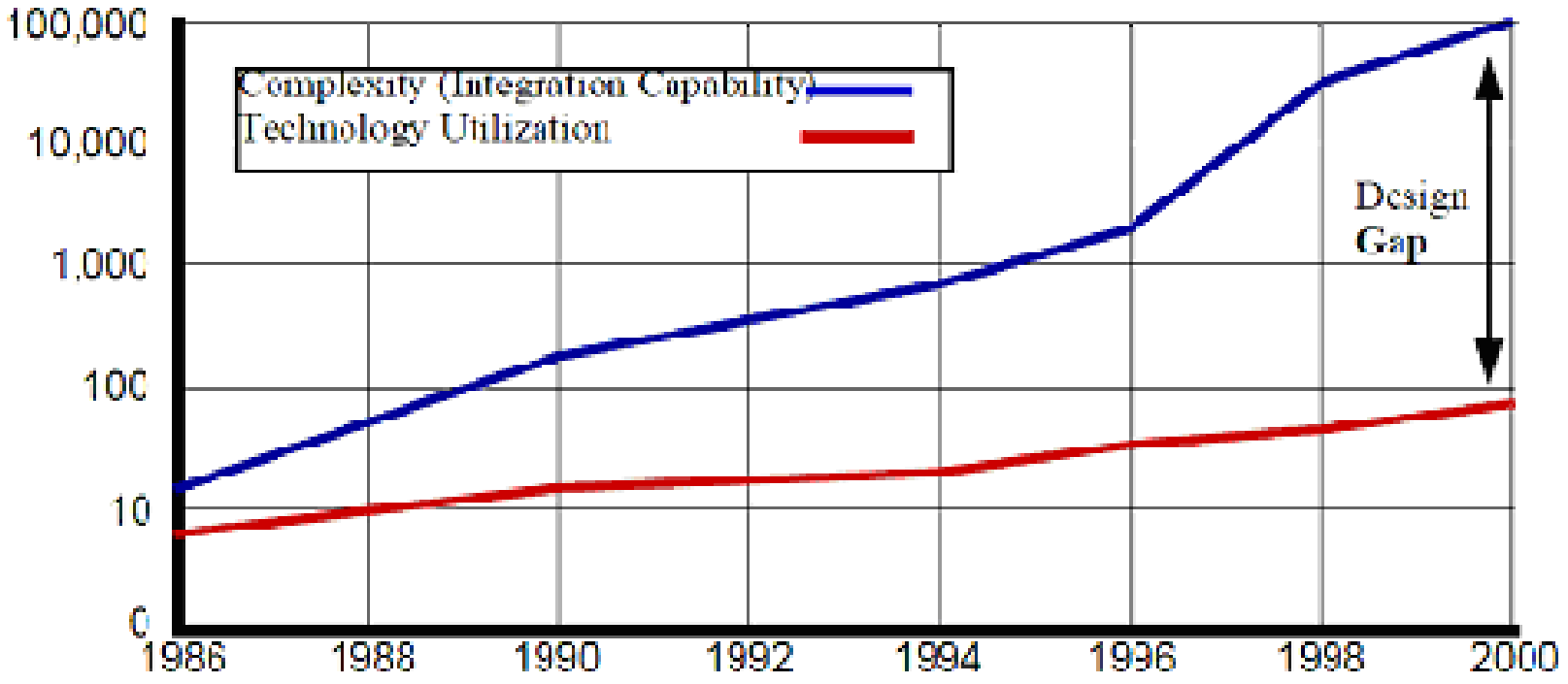
- There are several benefits in integrating a large digital system into a single integrated circuit .
- These include
  - Lower cost per gate .
  - Lower power consumption .
  - Faster circuit operation .
  - More reliable implementation .
  - Smaller physical size .
  - Greater design security .

The Drawbacks

- The principle drawbacks of SoC design are associated with the **design pressures** imposed on today's engineers , such as :

  - Time-to-market demands .
  - Exponential fabrication cost .
  - Increased system complexity .
  - Increased verification requirements .

Design gap


100,000
10,000
1,000
100
10
0
1986
1988
1990
1992
1994
1996
1998
2000
Complexity (Integration Capability)
Technology Utilization
Design Gap

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Solution is Design Re-use

- Overcome complexity and verification issues by designing Intellectual Property (IP) to be re-usable .
- Done on such a scale that a new industry has been developed.
- Design activity is split into two groups:
  - IP Authors – **producers** .
  - IP Integrators – **consumers** .
- IP Authors produce fully verified IP libraries
  - Thus making overall verification task more manageable
- IP Integrators select, evaluate, integrate IP from multiple vendors
  - IP integrated onto Integration Platform designed with specific application in mind

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Major SoC Applications

- Speech Signal Processing .
- Image and Video Signal Processing .
- Information Technologies
  - PC interface (USB, PCI,PCI-Express, IDE,..etc) Computer peripheries (printer control, LCD monitor controller, DVD controller,.etc) .
- Data Communication
  - Wireline Communication: 10/100 Based-T, xDSL, Gigabit Ethernet,.. Etc
  - Wireless communication: BlueTooth, WLAN, 2G/3G/4G, WiMax, UWB, …,etc

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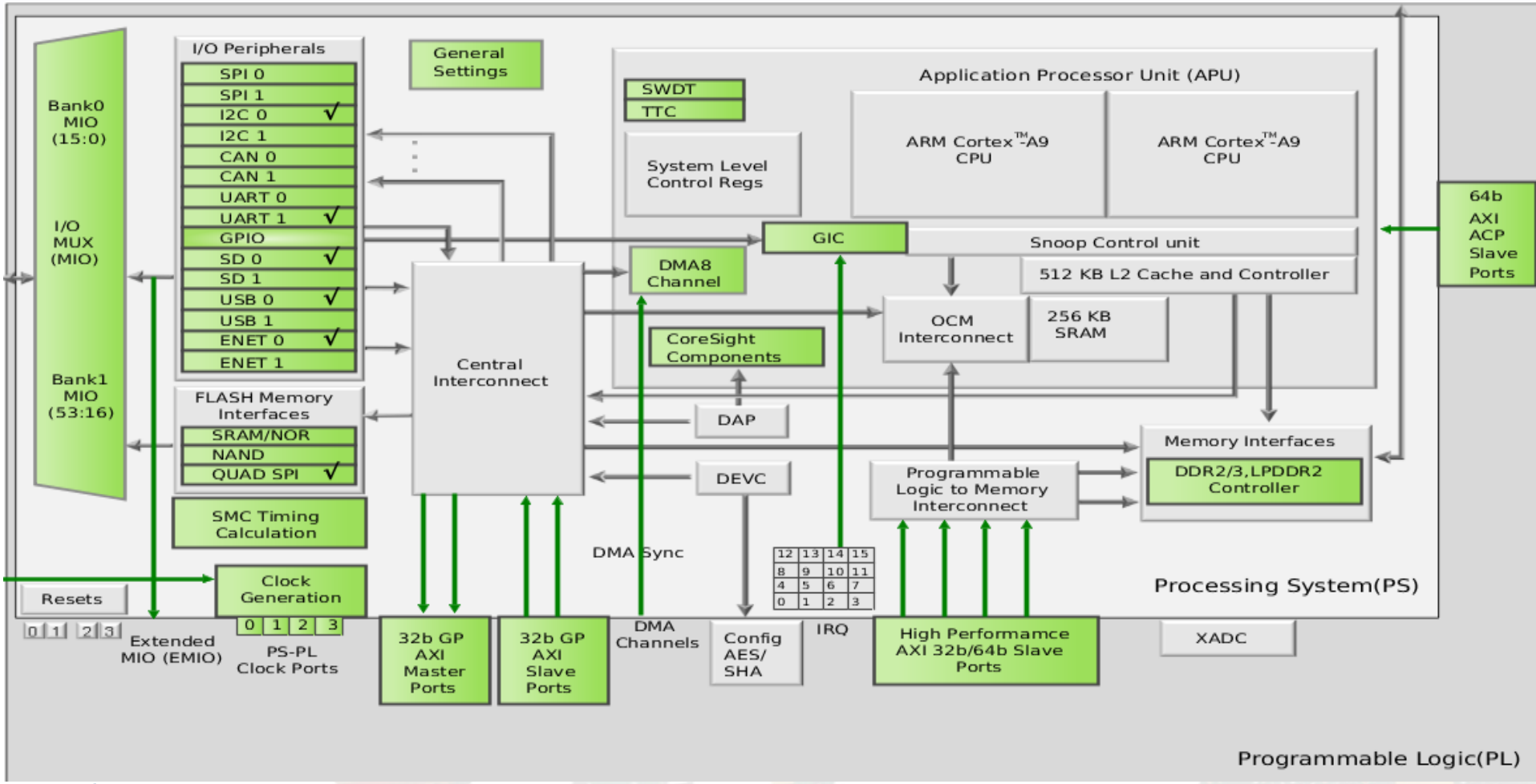
Summary

- Technological advances mean that complete systems can now be implemented on a single chip .
- The benefits that this brings are significant in terms of speed , area and power .
- The drawbacks are that these systems are extremely complex requiring amounts of verification .
- The solution is to design and verify re-useable IP .

Zynq SoC Platform



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