Microprocessors

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Introduction

Layers of computing

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High level

- Functional description/algorithm – high level language
- i.e. Temple runner, weather forecast estimator… - C, Java …

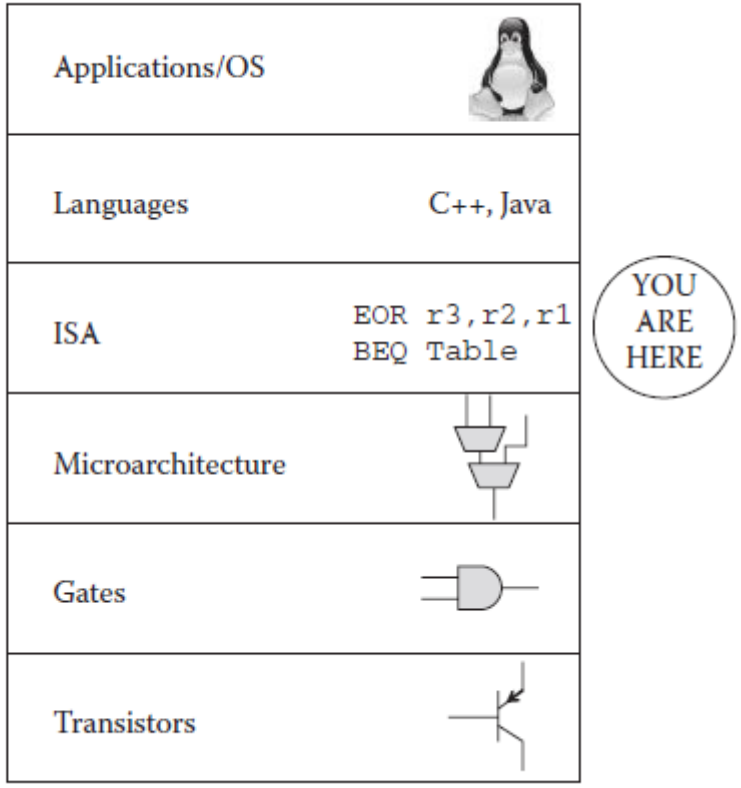
processor

- Machine – Assembly (will be converted to assembly anyway)
- Intel-8086, PC, ARM Cortex-A9

silicon

- Hardware – HDL, soldering…
- ASIC, FPGA, PLA, Memory + logic gates….

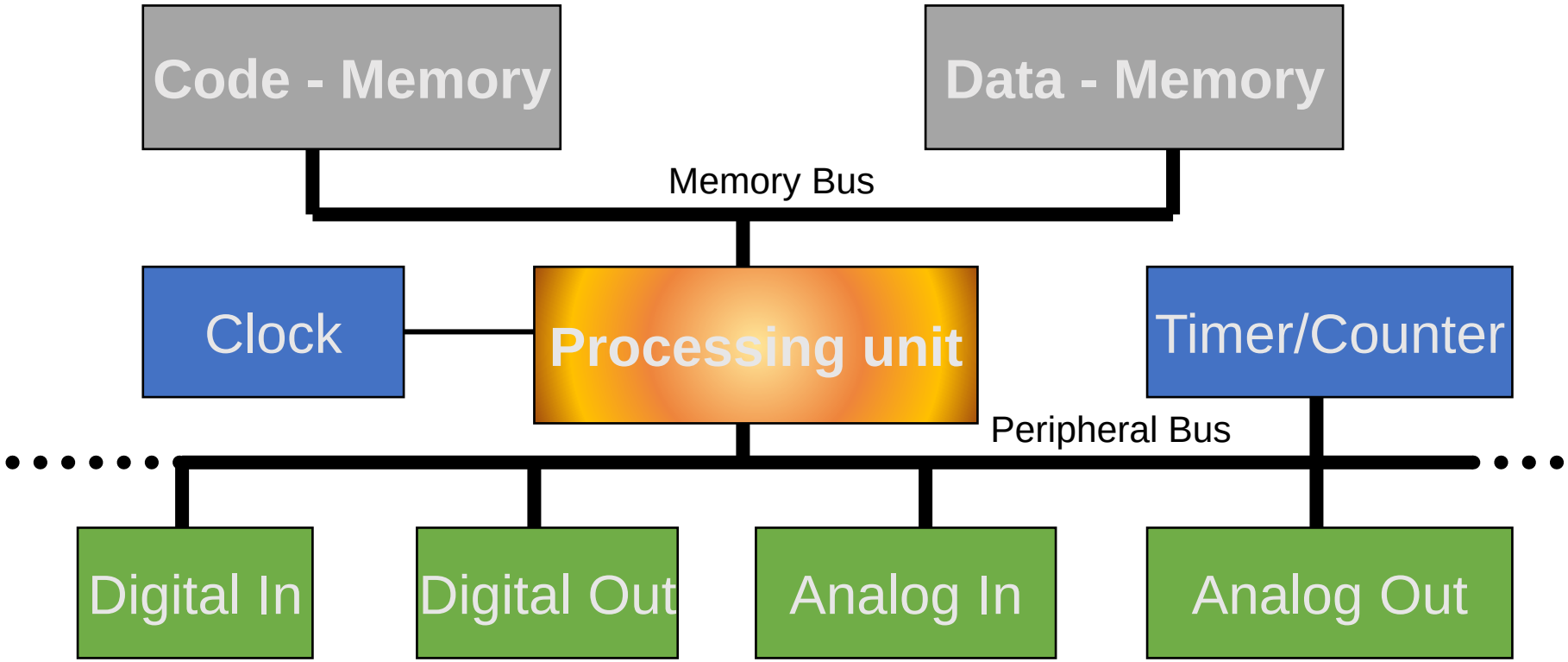
Layers of computing – detail



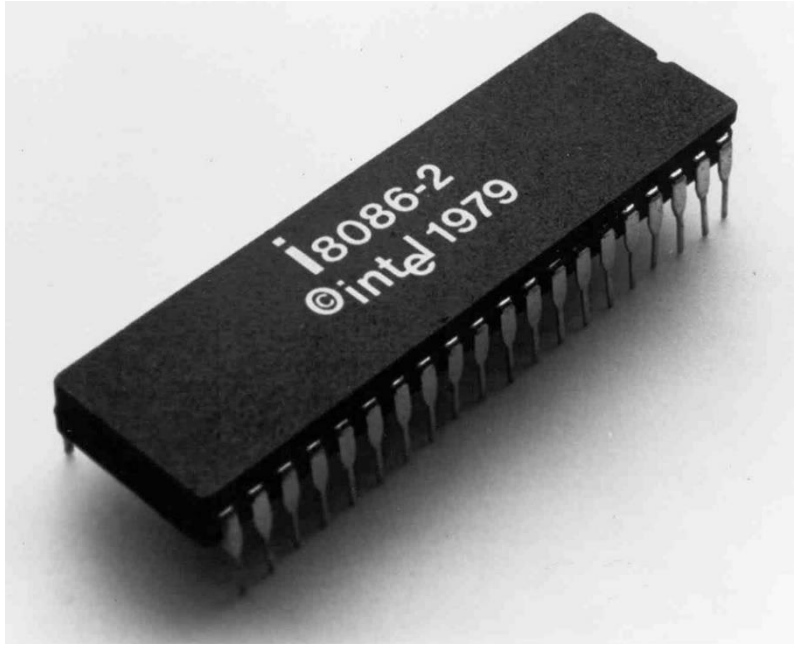
Micro-computing machines

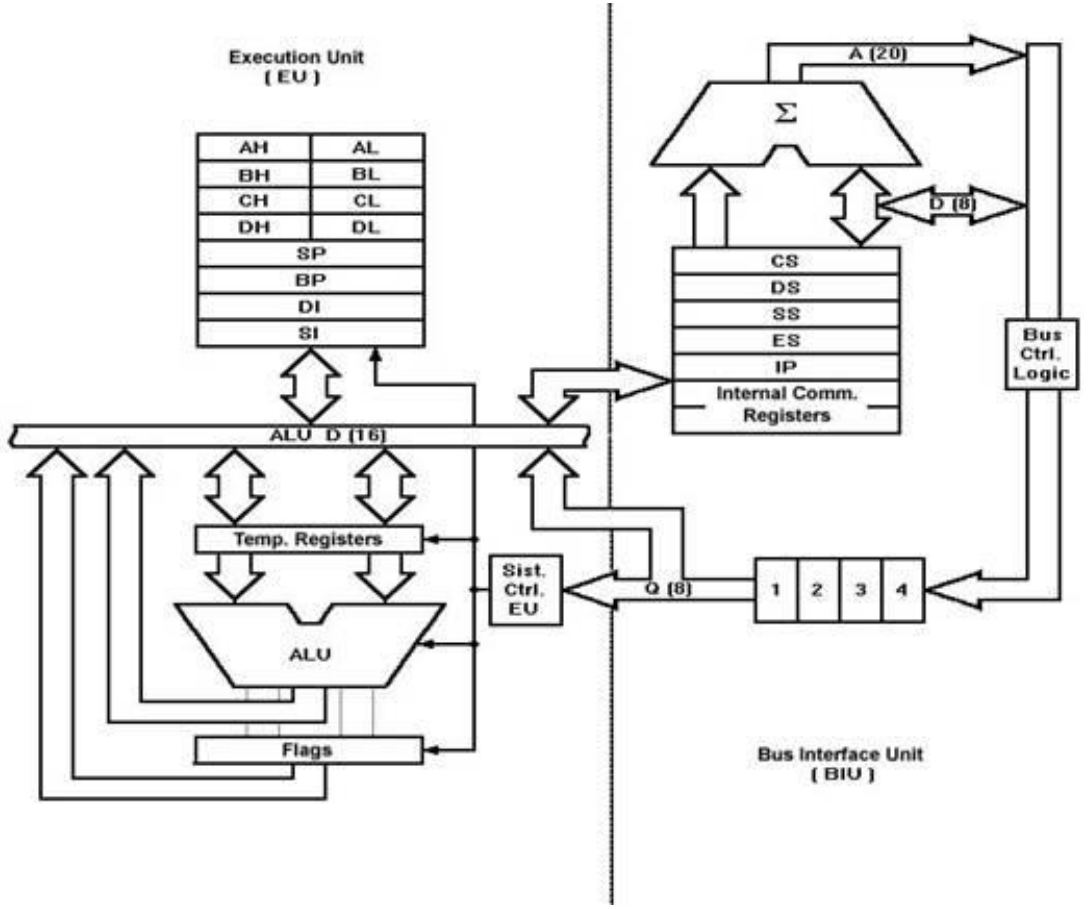
- Microprocessor (µP)
- Micro Computer: Microprocessor(µP) + Memory + Peripherals
- Microcontroller (µC): a Micro Computer as a single silicon chip.
- Digital Signal Processor (DSP): Additional hardware units to speed up computing of sophisticated mathematical operations for specific applications (audio, video processing etc.)

Micro-computing machines

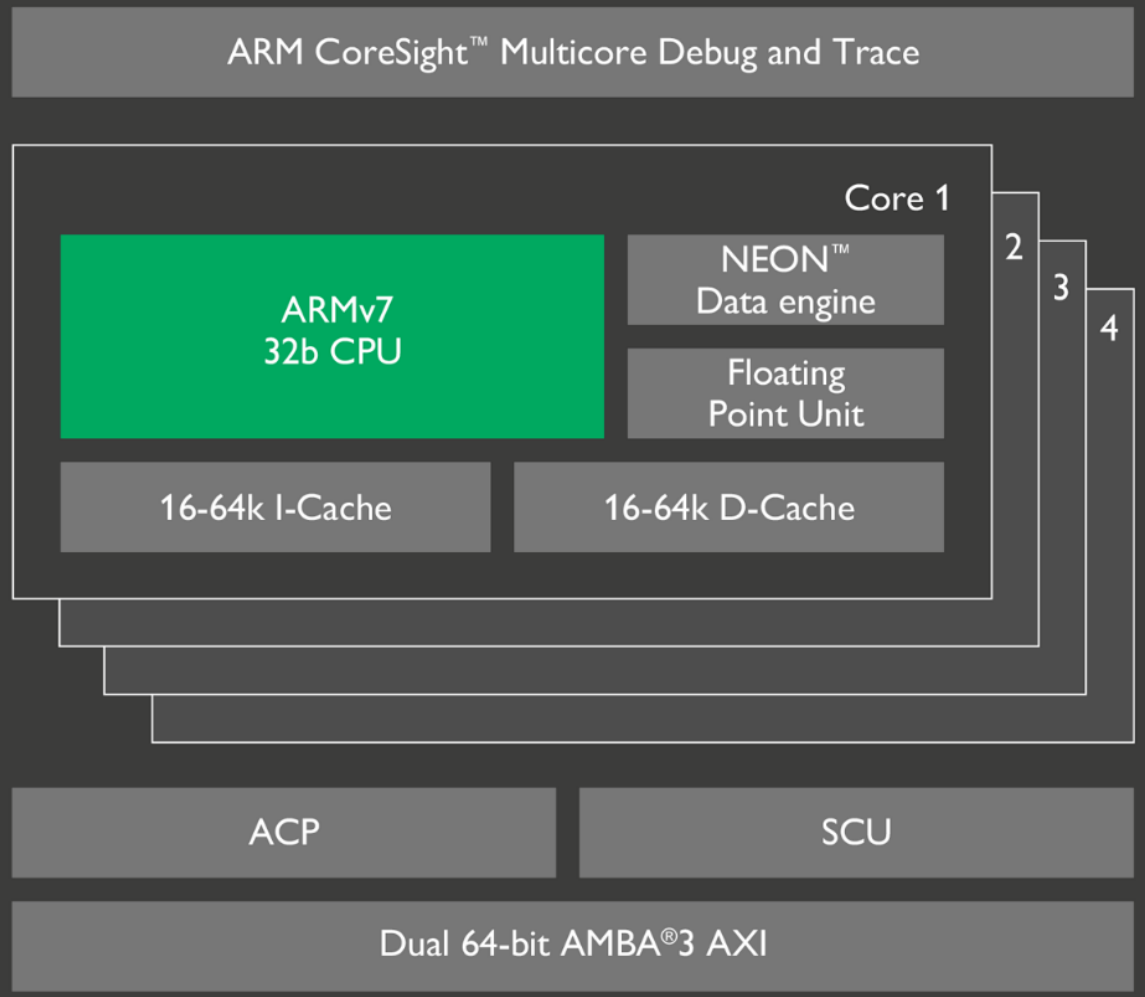


Intel 8086


i8086-2
©intel 1979


Execution Unit
(EU)
AH
AL
BH
BL
CH
CL
DH
DL
SP
BP
DI
SI
ALU D (16)
Temp. Registers
ALU
Flags
Sist. Ctrl. EU
A (20)
Σ
D (8)
CS
DS
SS
ES
IP
Internal Comm. Registers
Bus Ctrl. Logic
Q (8)
1
2
3
4
Bus Interface Unit
(BIU)

ARM Cortex®-A9



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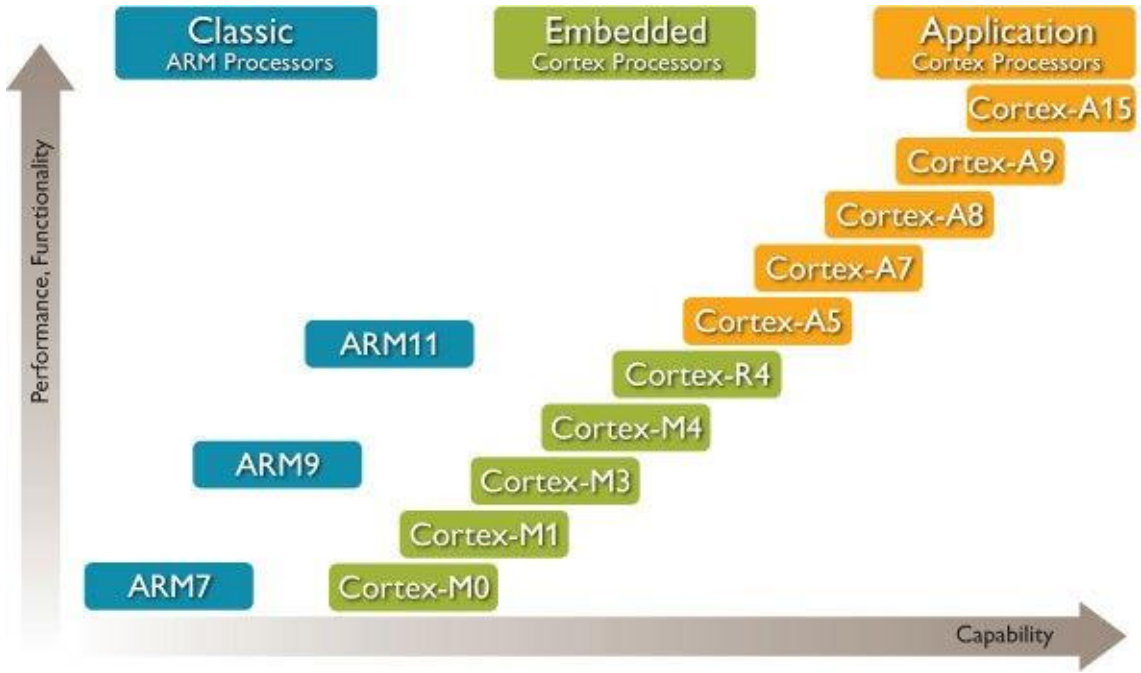
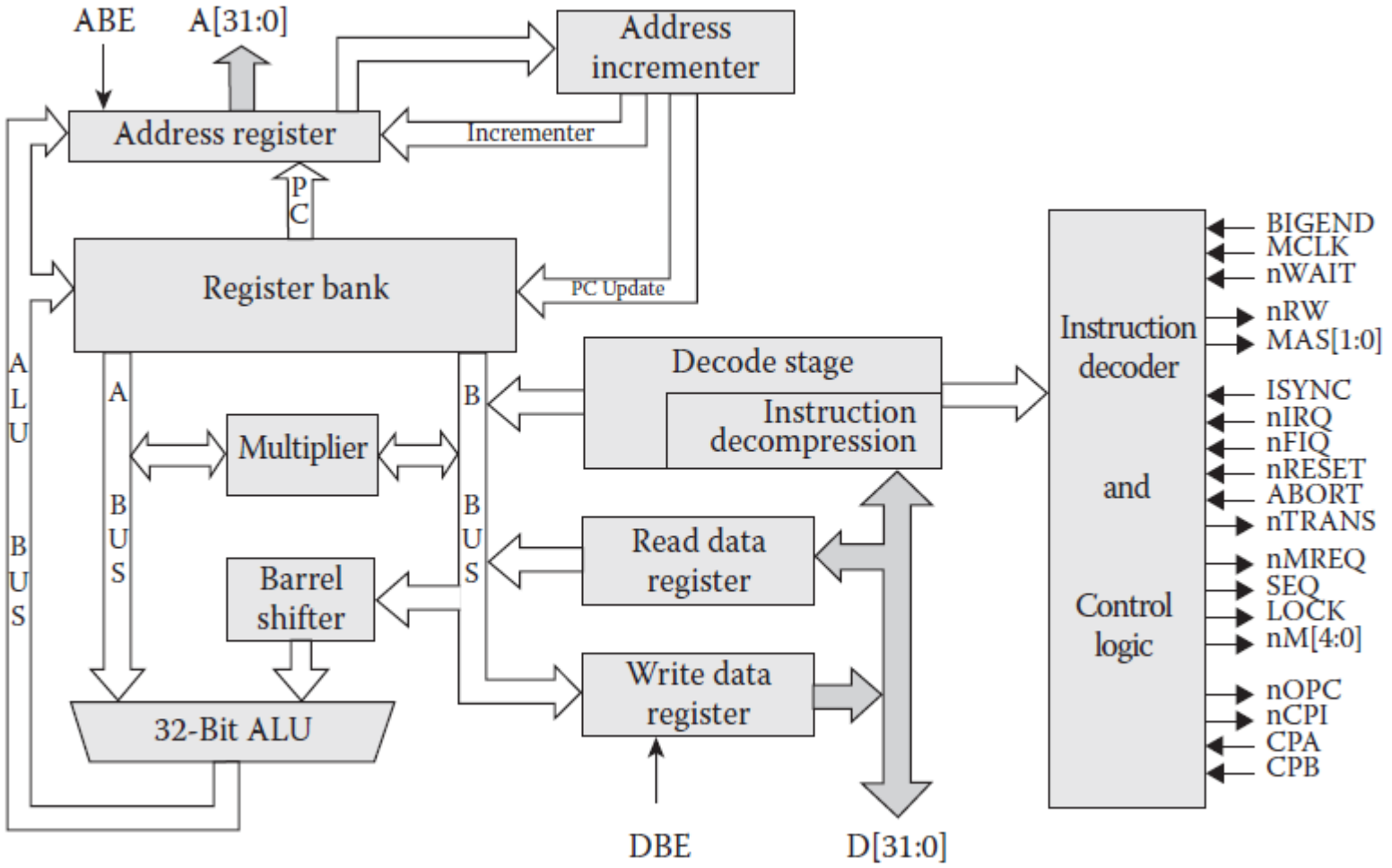


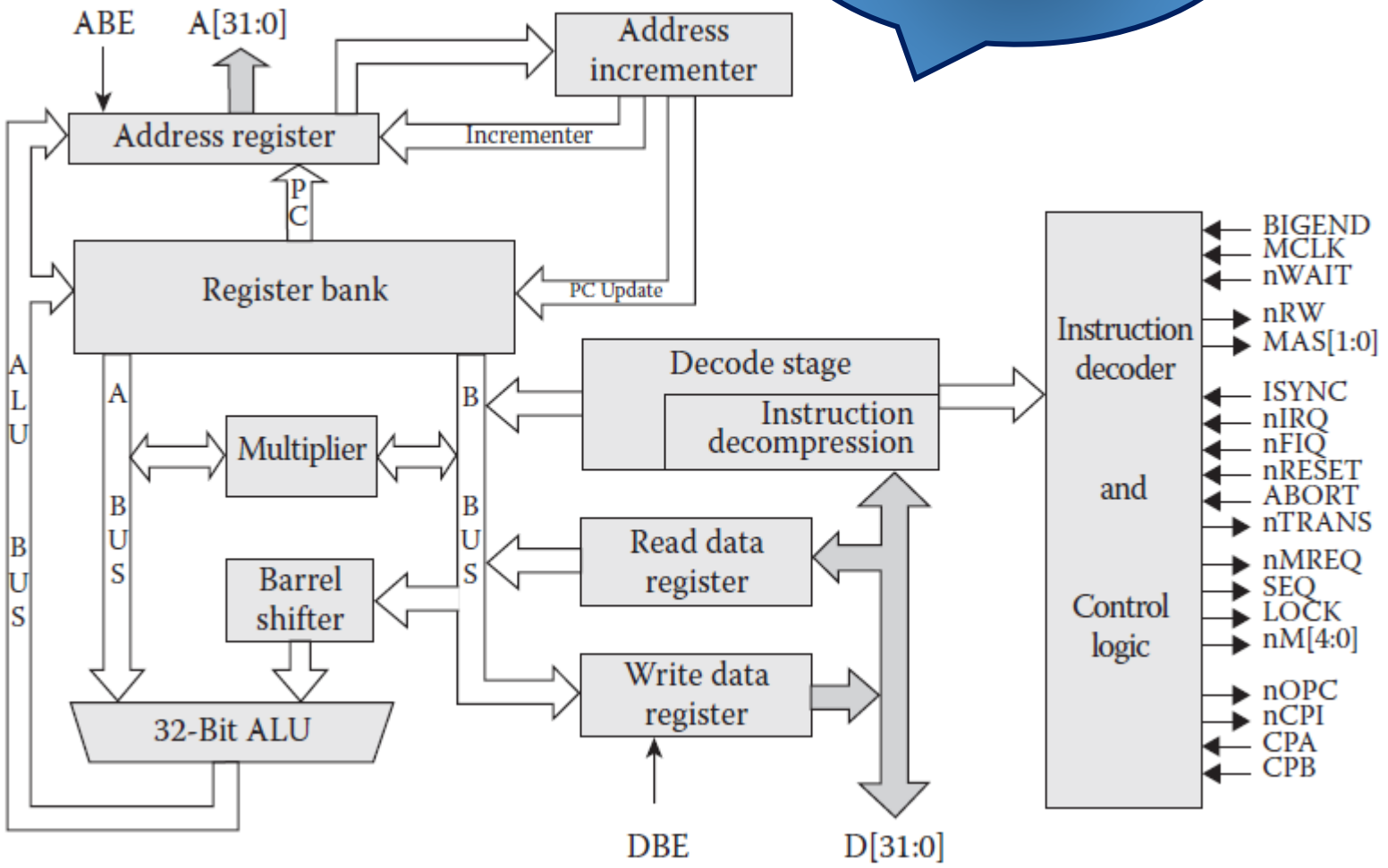
ARM7



Ref. ARM Assembly Language Fundamentals and Techniques

ARM7

Which blocks are familiar?



Ref. ARM Assembly Language Fundamentals and Techniques

Introduction to computer systems with ARM

ARM Assembly Language, Fundamentals and Techniques, William Hohl

Christopher Hinds, ch 1.

System around a uP

- Today's computing devices use SoC: System on Chip
  - a combination of processors, memory, and graphics chips that have been fabricated in the same package to save space and power.
  - SoC designs are sophisticated.
  - ~6 months market time.
- Save design time:
  - Reuse some of previous versions.
  - Use "intellectual property": designs and concepts that can be licensed to other companies for use in large projects.
  - i.e. Rather than design a microprocessor from scratch companies will take a known design, (maybe from ARM), and build a complex system around it.

System around a uP

- Standards: pieces of the project are often designed to comply with certain standards so that when one component is changed, engineers can reuse all the surrounding devices.
  - i.e. I/O port standards and buses (like AMBA)
- Microcontroller industry:
  - Very simple processors can be combined with useful extras such as timers, universal asynchronous receiver/transmitters (UARTs), or analog-to-digital (A/D) converters to produce a microcontroller,
  - A very low-cost device for use in industrial controllers, displays, automotive applications, toys, and hundreds of other places one normally doesn't expect to find a computing engine.

RISC and CISC Instruction Sets

- Reduced Instruction Set Computers (RISC):
- Each instruction must fit into a single word reduces the complexity and the number of different types of instructions that may be included in the instruction set of a computer.
- A load/store architecture is used, in which
  - Memory operands are accessed only using Load and Store instructions.
  - All operands involved in an arithmetic or logic operation must either be in processor registers, or one of the operands may be given explicitly within the instruction word.
- Complex Instruction Set Computers (CISC).

Course Outline

1.	Welcome!
2.	Introduction to computer systems, Number systems, binary arithmetic and data representation The architecture of microprocessor
3.	Instruction set: Load, Store, Addressing modes
4.	Instruction set: logic instructions and arithmetic instructions
5.	Instruction set: Branches and loops
6.	Sub-routine and stack operation, Programming the microprocessor with examples
7.	Basic I/O interface
8.	Memory interface
9.	Interrupts
10.	Programming practice (using interrupts)
11.	Direct Memory Access (DMA)
12.	Microprocessor-based system design
13.	Arithmetic co-processors
14.	Advanced methods in microprocessor-based system design: multi-core systems, GPU, TPU …etc.

Lab Outline

Topics that will be covered in lab:

1. Using an ARM Cortex-A9 System and CPULATOR
2. Using Logic Instructions with the ARM Processor
3. Subroutines and Stacks
4. Input/Output in an Embedded System
5. Using Interrupts
6. Peripherals
7. Microprocessor based system design

Grading

	Number	Ratio (%)
Midterm Exam	1	20
Final Exam	1	20
Labs	5	30
Project	1	20
Quiz/assignment	?	10
Total		100

Conditions!

1. Lab attendance: 5/7
2. Exam average: 20/100
3. Labs+class: 30/60
4. Working Final project: 20/100
5. Weigted average: 45/100

Course Material

- Text books on «computer organization» follow very similar pattern. You can use your book from computer architecture course. (i.e. Computer organization and design, D. Patterson and J. Hennessy; Computer Architecture and Organization, J.P. Hayes…)
- An online C.org book: «Computer Organization And Embedded Systems», Hamacher, Vranesic, Zaky, Manjikian, 6Ed, Mgh, 2012 (pdf online by the authors permission)
- **ARM ASSEMBLY LANGUAGE, Fundamentals and Techniques, William Hohl and Christopher Hinds, 2015**
- **ARM Cortex-A9 microprocessor tutorials, instruction set and DE1-SoC manuals – online.**
- Lecture notes on Blackboard

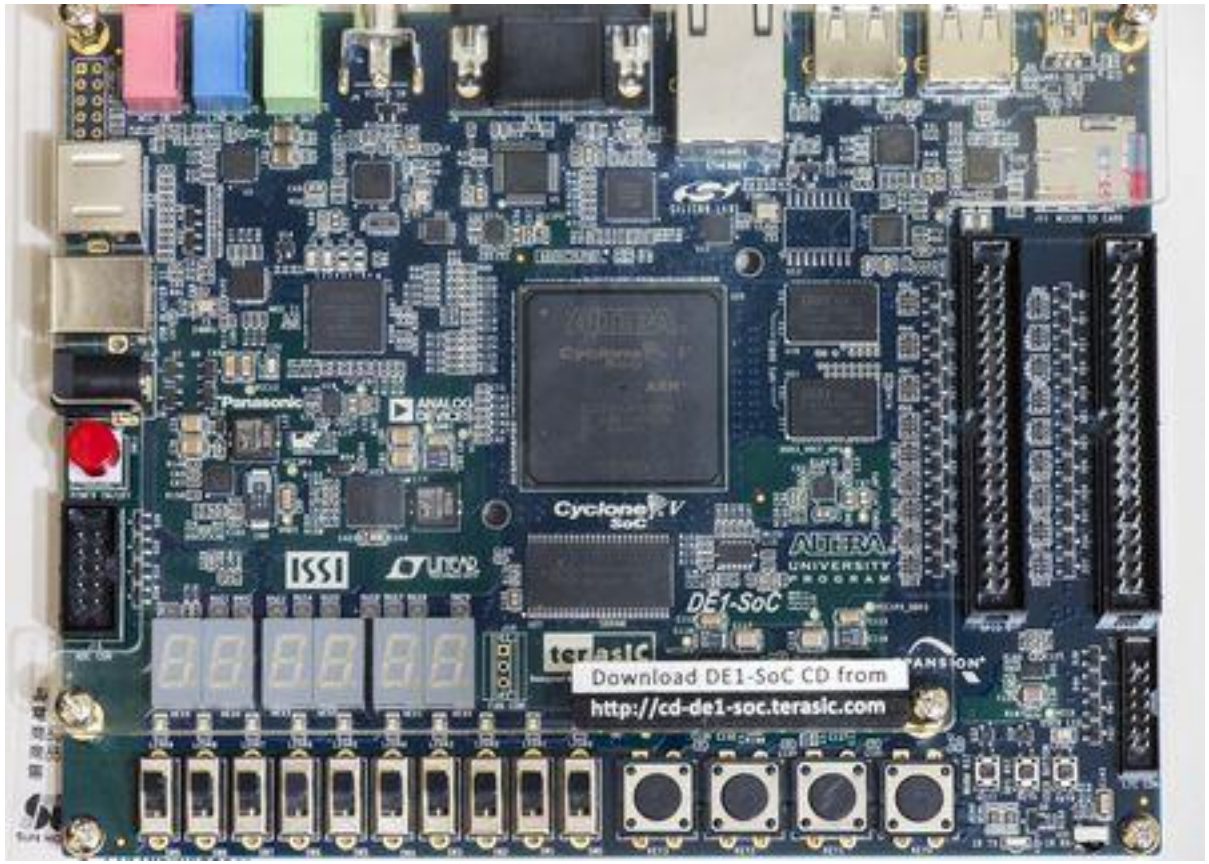
Lab rules

- General lab rules follow.
  - Don’t be late to your scheduled lab session.
- Make-up:
  - Only 1 make-up is possible with proper documents
  - Should be scheduled in the first final/presentation week (week 15).
- Grading:
  - 20 points per task: ~~report~~, in lab, and prep activity.
- In lab- prep. activity:
  - Task is completed and student has deep understanding on the subject
  - Task is completed
  - Code is working but does not completely does what supposed to do
  - Code is not working at all or no collaboration effort.
- http://cpulator.01xz.net/?sys=arm-de1soc
- Look up Altera DE1-SoC guides, when needed.

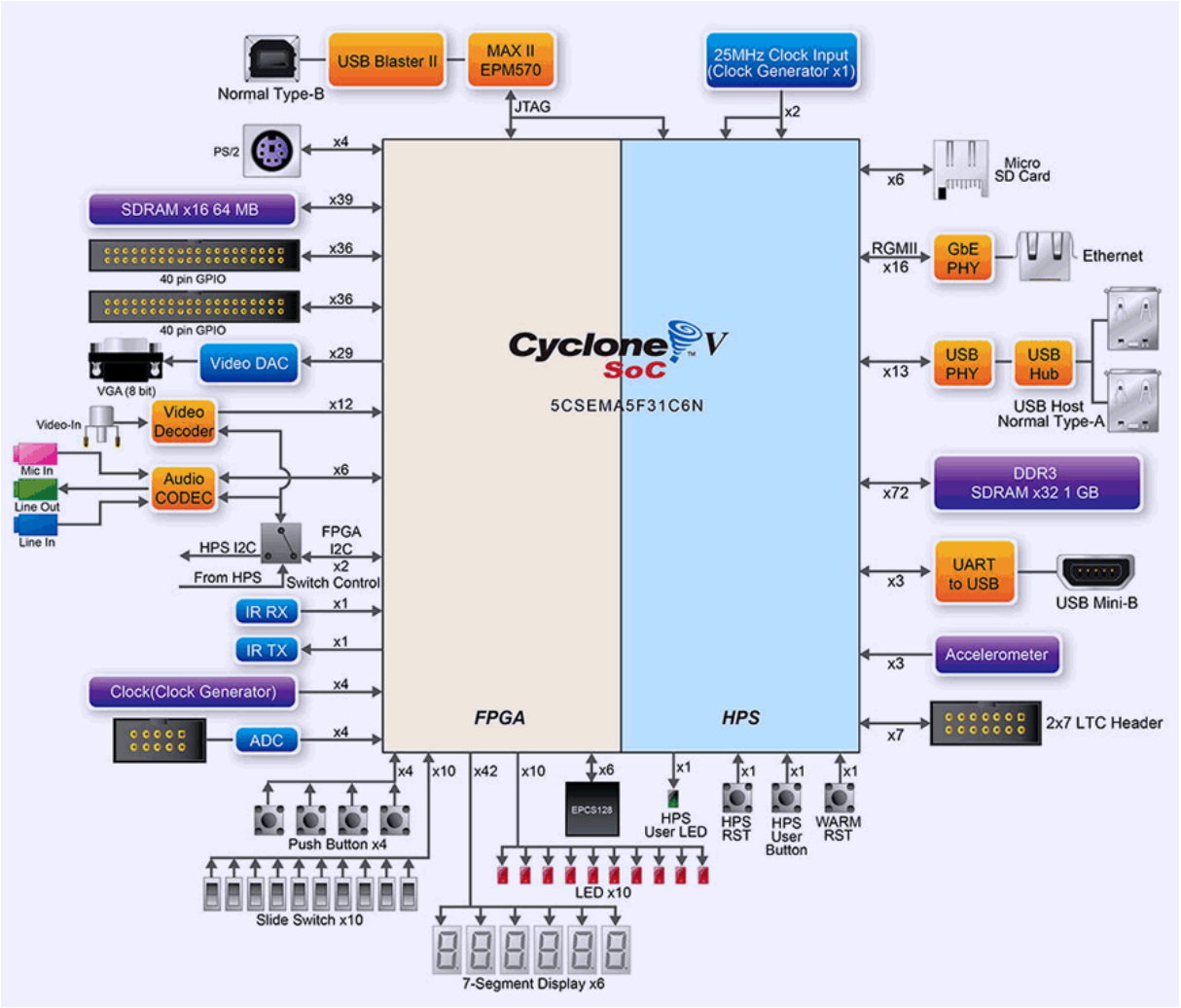
~~Lab report grading (over 10)~~

- Program source code
  - 3 pts = good/excellent
  - 2 pts = needs improvement
  - 1 pt= poor, but does what it was supposed to do
  - 0 pt= program does not work at all
- Explanations in the source code
  - 3 pts = well commented, easy to follow.
  - 2 pts = average comments, but not easy to follow.
  - 1 pt= poorly commented, doesn't explain the operation.
  - 0 pt= very little or no comments.
- Explanations –flowchart
  - 1 pts = enough level of detail to implement the complete functionality
  - 0 pts = no flowchart or impossible to write a working program
- Explanations –general writing (Technical understanding and writing)
  - 3pts = detailed technical background (i.e. configuration is explained step by step)
  - 2pts = good
  - 1pt= poor, but gives the basic description
  - 0 pt = not present or very little

DE1 – SoC


Cyclone V
SoC
ISSI
DE1-SoC
Download DE1-SoC CD from
http://cd-de1-soc.terasic.com

DE1 – SoC


USB Blaster II
MAX II EPM570
Normal Type-B
JTAG
25MHz Clock Input (Clock Generator x1)
x2
PS/2
x4
SDRAM x16 64 MB
x39
40 pin GPIO
x36
40 pin GPIO
x36
Video DAC
x29
VGA (8 bit)
Video-In
Video Decoder
x12
Mic In
Line Out
Line In
Audio CODEC
x6
HPS I2C
FPGA I2C
x2
From HPS
Switch Control
IR RX
x1
IR TX
x1
Clock(Clock Generator)
x4
ADC
x4
Cyclone V SoC
5CSEMA5F31C6N
FPGA
HPS
Micro SD Card
x6
RGMII
x16
GbE PHY
Ethernet
x13
USB PHY
USB Hub
USB Host Normal Type-A
x72
DDR3 SDRAM x32 1 GB
x3
UART to USB
USB Mini-B
x3
Accelerometer
x7
2x7 LTC Header
x4
x10
x42
x10
x6
x1
x1
x1
x1
Push Button x4
EPCS128
HPS User LED
HPS RST
HPS User Button
WARM RST
LED x10
Slide Switch x10
7-Segment Display x6

DE1 – SoC computer

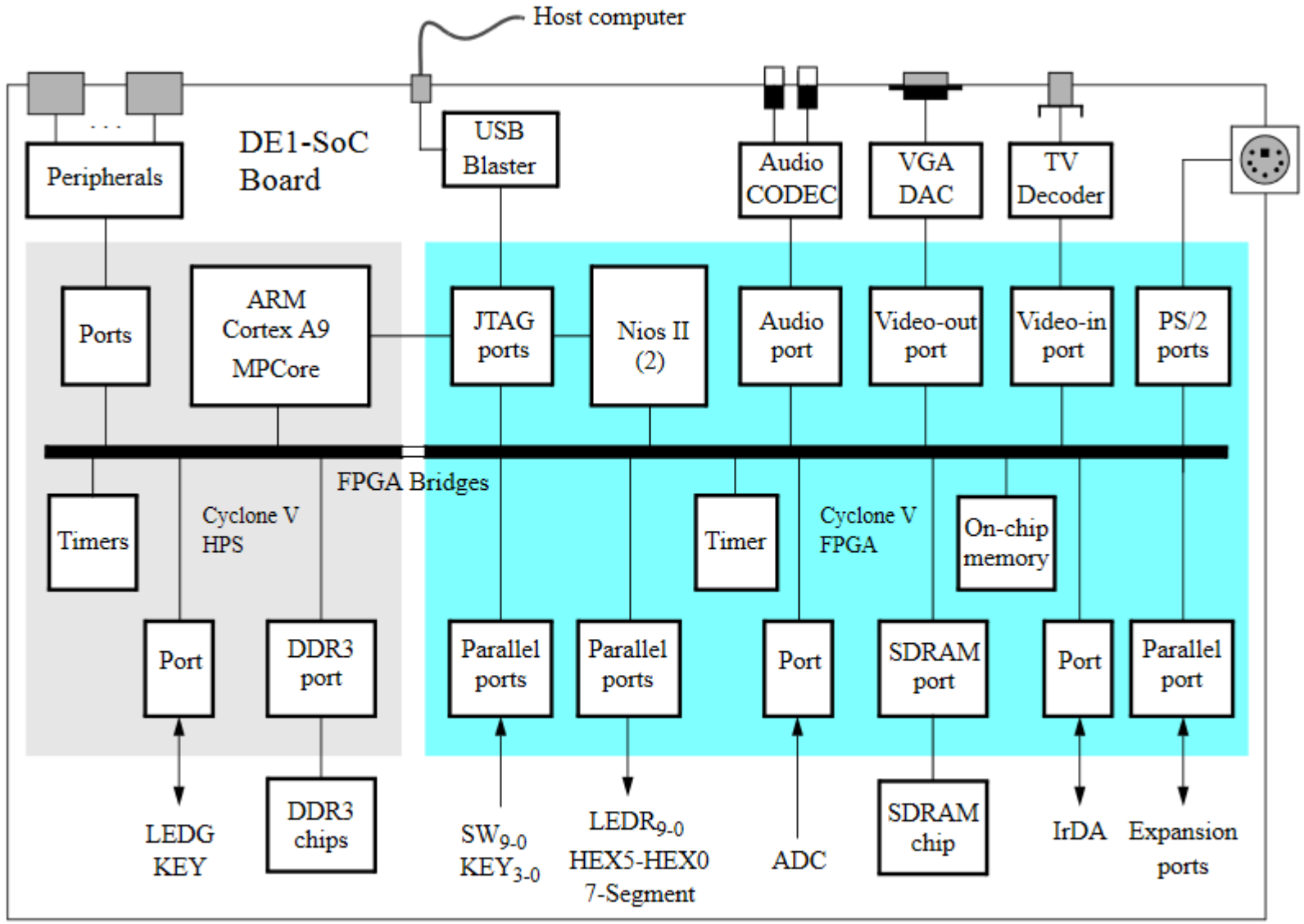
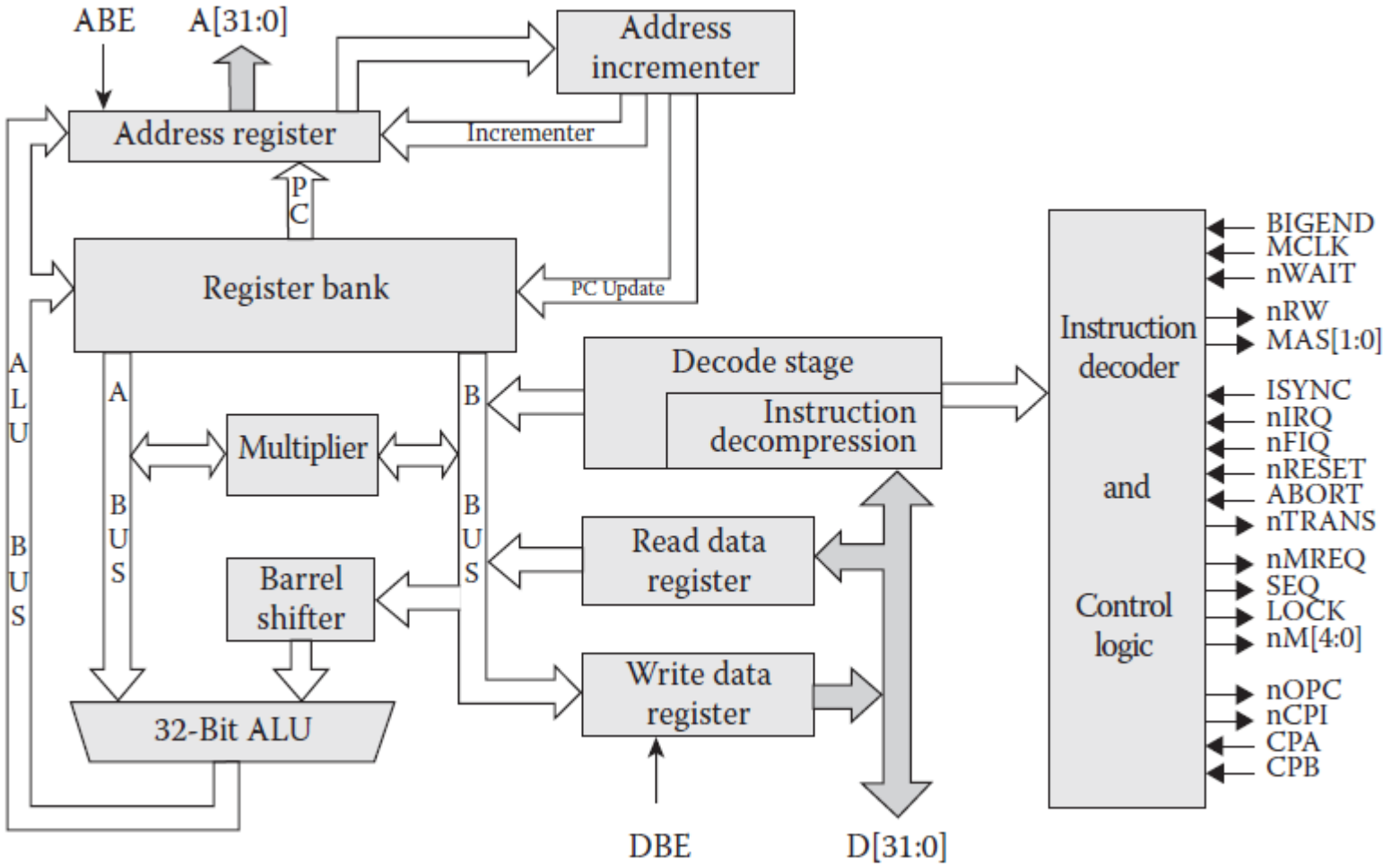


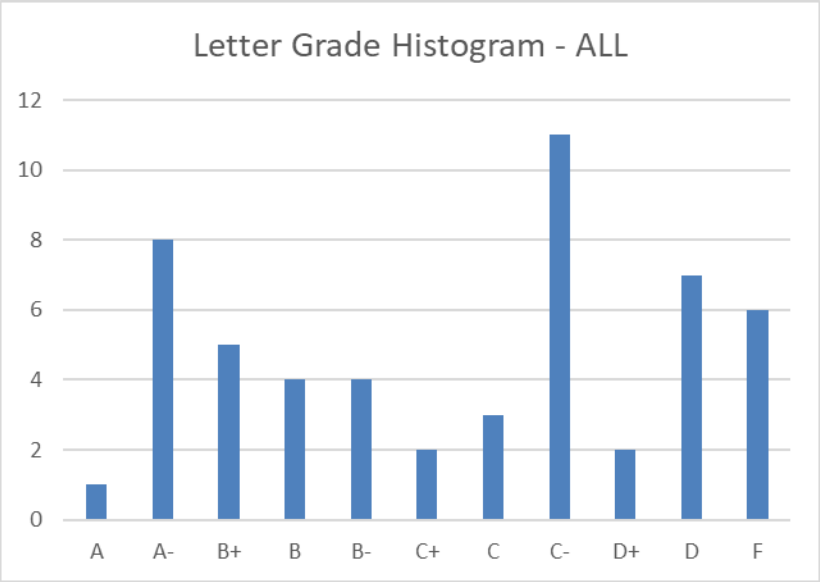
Figure 1. Block diagram of the DE1-SoC Computer.

ARM7



Ref. ARM Assembly Language Fundamentals and Techniques

Myths and Tips – 2020



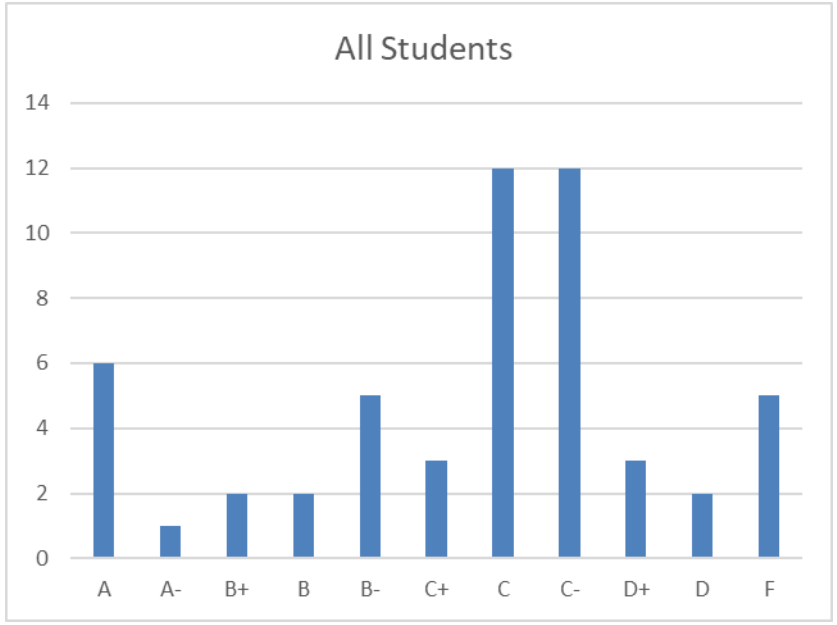
Total	Letter	Dept
86,43853	A	ELE
81,225	A-	ELE
81,12176	A-	COMP
81,42	A-	COMP
78,815	A-	COMP
79,60313	A-	ELE
79,885	A-	ELE
79,48167	A-	COMP
79,01	A-	COMP

Changes made	**Contributions to the improvement of the course**
Course schedule is updated: First week topics (CO1, CO2) should be refined in order to avoid rush in the following weeks (suggested last year: Weekly course plan can be changed to provide more hours for CO4-5.)	This way, there is more room for system design.
Pre-course quizzes are added (not graded). (suggested last year: Questions of quizzes can be added to flipped-learning videos.)	This is a more attractive pre-class study material. Videos were watched by a few students in the previous years, but this year half of the students came to class prepared.

- *"Bence dersin tek eksi yönü, çok fazla sorumluluğu var. Öğrenme açısından güzel bir şey fakat sınav haftalarında ve diğer derslerin de lablarıyla çakışınca çok zor oluyor. Biraz daha azaltılabilir."*
- "yoğun bir ders olduğu için ders saati olarak daha erken saatte olursa öğrenciler daha aktif olabilir."
- *"diğer hocalarımdan aldığım 3 bölüm dersime 2 birim vakit ayırdıysam, Tuba hocadan aldığım 2 derse 4 birim vakit ayırmışımdır."*

- Monday afternoon, not bad.
  - HWs are turned into real quizzes (we have 4 hours, not 3 ☺).
  - Take note!
- Pre-course study quizzes stay.
- Design scores were low: 1 uP based design lab is added, project expectations are increased, written final exam is gone.

Myths and Tips – 2021



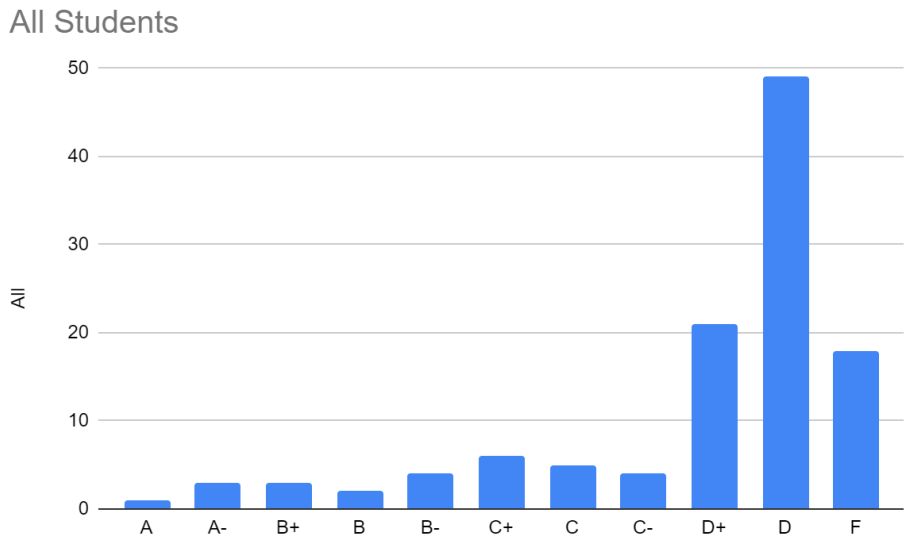
Total	Letter	Dept
95.35	A	EE
94.75	A	COMP
94.575	A	EE
93.85	A	COMP
93	A	EE
92.85	A	COMP

Changes made	Contributions to the improvement of the course
…..	All Covid-19 related…

- *"After our Computer Architecture course, this course completed the incomplete parts. Also, our instructor encouraged us not just learning to the course topics but even to research and to learn real-life implementations of the course topics.."*
- *"Ders öncesi flipped yaparak derse girdiğimde çok daha iyi anladım. Tuba hoca çok fazla yapacak şey veriyor, fakat bence bunların çok olması sorun değil. Çünkü bu sayede hem biz daha iyi evaluate ediliyoruz hem de sürekli bir şeyler yaptığımız için bilgi beynimizde daha taze kalıyor diye düşünüyorum.*
- *"4 saatlik ders bence öğrenciyi yoruyor ama bu ders zaten bölümün konsept olarak en zor dersi."*

- Monday morning, 3 hours, not bad.
  - Back to HW or take-home (?) quizzes.
  - Take note!

Myths and Tips – 2024



- Surprisingly low grades ☹

If the program outcome result is lower than 2,5, it means that necessary precautions must be taken.

SO1 is related to CO1. Its score is getting lower every year. This outcome is related to the first half of the course in terms of weekly schedule. As stated in section 7, more tools (hw, quiz, class practice etc.) will be used to keep the students engaged in the first weeks.

Changes proposed	Aim of the change
• Increase the number of quizzes. Last year, "Give homework assignment and limit its effect to max. %20." Was suggested but thanks to chatgpt, I cannot see the level of students correctly.	• Students pushed all towards exams so that the success is decreased. Quizzes can a be a motivation to keep the students in track. • Suggested in Surveys (22-23).

Anket Sonuç

Instructor	TUBA AYHAN	**Öğrenci Sayısı**	117
Course Code.Section	EE 306.00	**Cevap Adedi**	6
Academic Year/Semester	2023-2024/2	**Cevaplama Oranı**	%5.13

Written Comments
Please use the space below for any additional comments you might have.
* Dersin geçme koşullarının bu kadar sert olması doğru gelmiyor. İş yükü ve zorluğu fazla olan bir derste dersten kalma korkusu ancak çalışma verimimizi düşürüyor. Bunun dışında Tuba Hocanın anlatımına derse hakimliğine diyecek bir şey yok. Kendisi son derece iyi bir akademisyen...
* Tuba hoca çok mükemmeliyetçi. Her şeyden en iyisini istiyor. Ama istediği sanki 10 yıldır bu alanda çalışan birinden istediği cevap. Ayrıca bir bilgisayar öğrencisinin bu kadar derinlemesine bir konuyu bilmesine gerek yok. Bütün bilgisayarcı arkadaşlarımla konuşuyoruz ve kimse bu alanda bir şey yapmayacak, geliştirmeyecek. Arm-assembly dilinden soğudum. Her yıl bir sürü öğrenci daha ilk midterm sonrasında dersten kalıyor, bu kabul edilemez bir şey. Üniversite yönetimi hocanın ders kurallarını belirlemesine izin verdiği için öğrenciler dersten kalıyor ve geçemiyor. Midterm'den 20 altı alırsanız kalıyorsunuz. Eğer öğrenci finale çalışıp, lablardan yüksek alırsa belki geçecek ama bu yönüyle öğrenci kalıyor bir sonrakı yıla kadar bekleyip alması gerekecek. Üniversite yönetiminin bu konuda bir adım atması lazım, hocalara geçme kalma gibi standartlar koyması öğrencilerin dersten kalmasına ayrıca hatta okulu bu ders yüzünden veremeyen öğrenciler var. Bir anket açılırsa bu dersi öğrenen veya seven konusunda yüzde 10 kişiyi geçeceğini sanmıyorum.