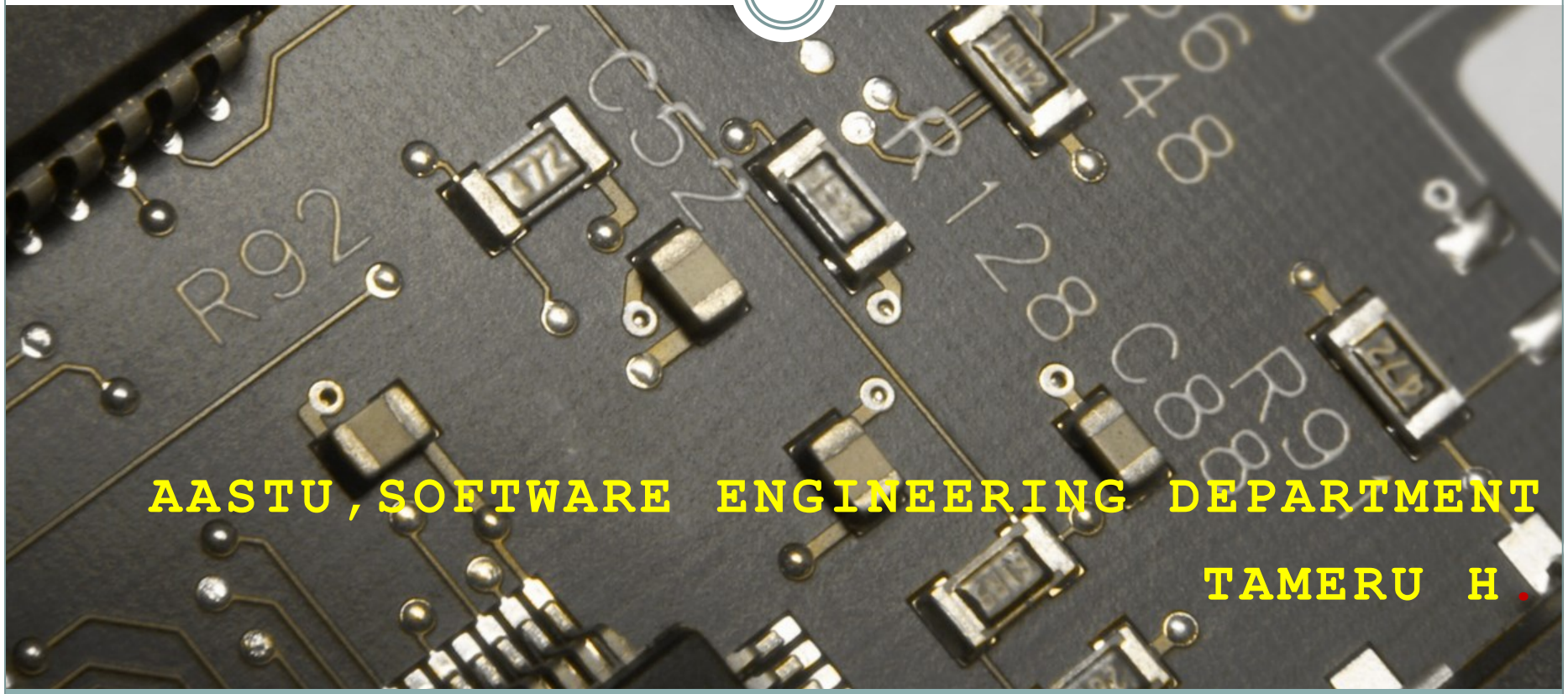
Chapter Two

Part-1

Computer Evolution



AASTU, SOFTWARE ENGINEERING DEPARTMENT

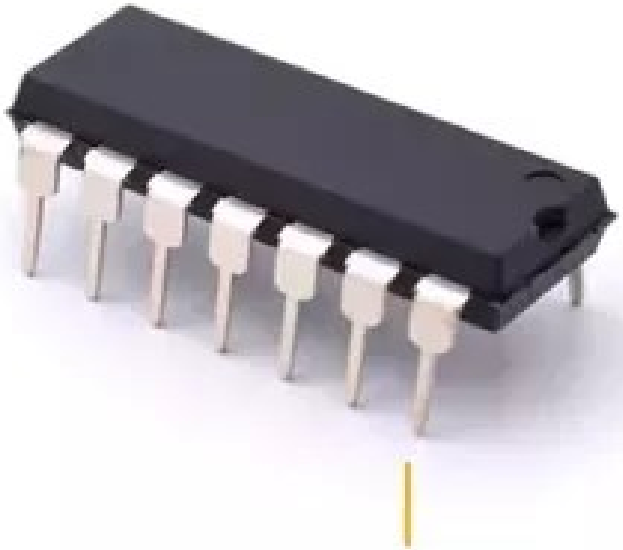
TAMERU H.

Computer Generations

First Generation: Vacuum Tubes

Vacuum tubes: slow, expensive, fragile

Transistors: much simpler, much smaller, much cheaper, more reliable, no warm up, much faster.

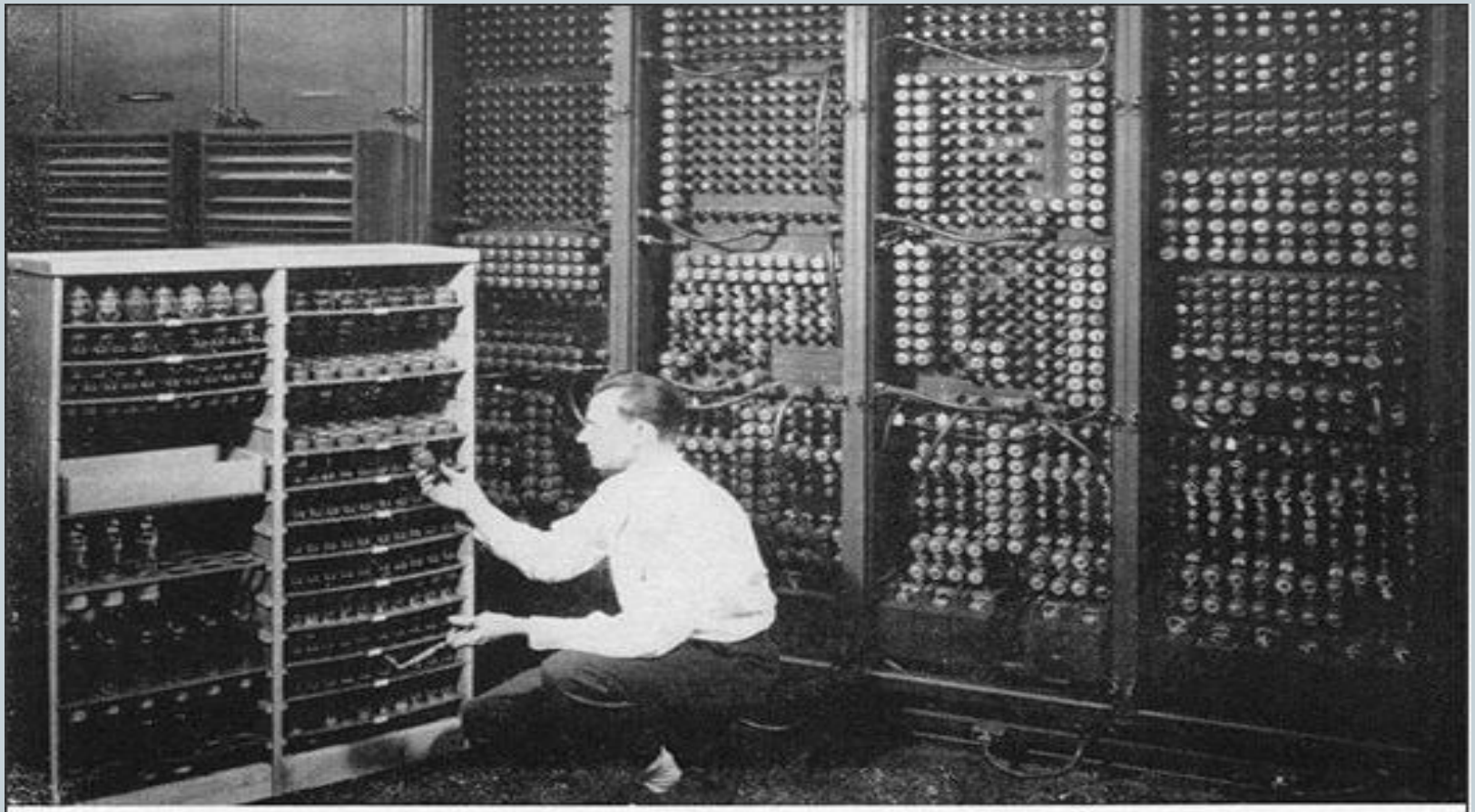


Integrated circuits: miniaturization added to all the existing benefits, enabled unthought-of possibilities

ENIAC
(Electronic Numerical Integrator And Computer)

- **ENIAC** (Electronic Numerical Integrator And Computer), designed and constructed at the University of Pennsylvania.
- The world's first general purpose electronic digital computer.
- Machine was enormous, weighing **30** tons, occupying **1500** square feet of floor space, and containing more than **18,000** vacuum tubes.
- The ENIAC was a decimal rather than a binary machine.

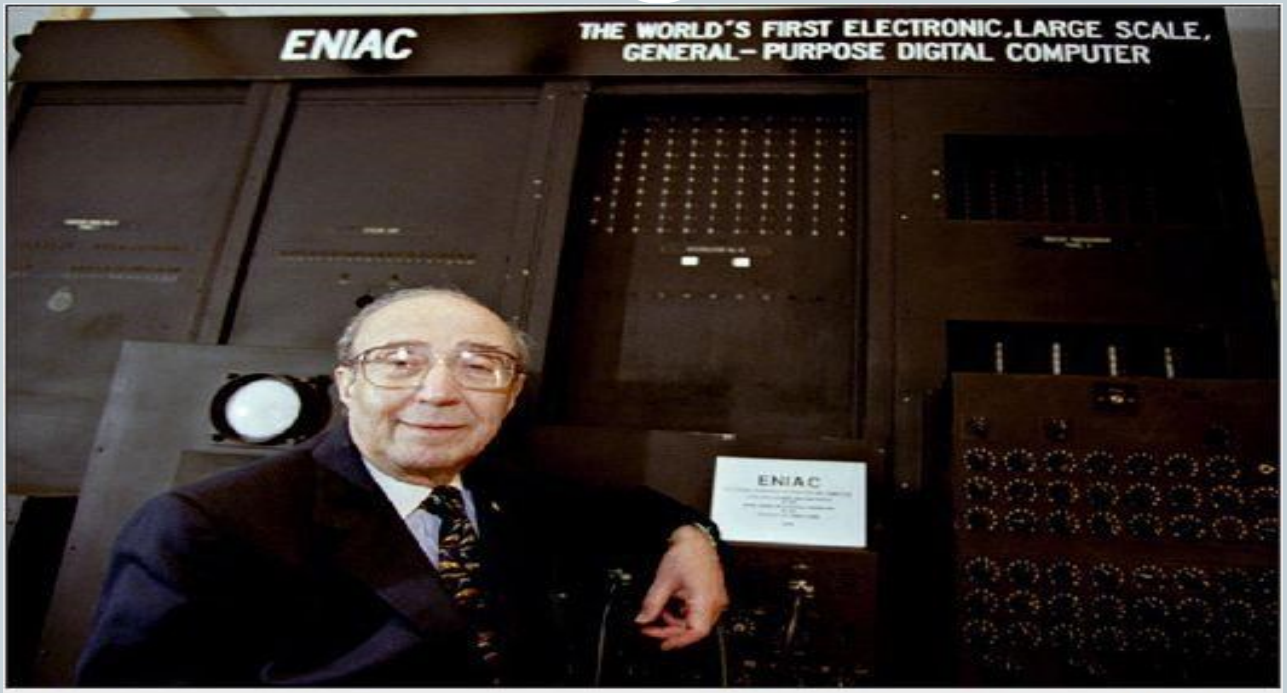
Cont'd…



Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.

Credit: U.S. Army photo

ENIAC chief developer



Credit: Reuters

- **John Mauchly**, a professor of Electrical Engineering at the University of Pennsylvania,

Six women who programmed ENIAC

THE VON NEUMANN MACHINE

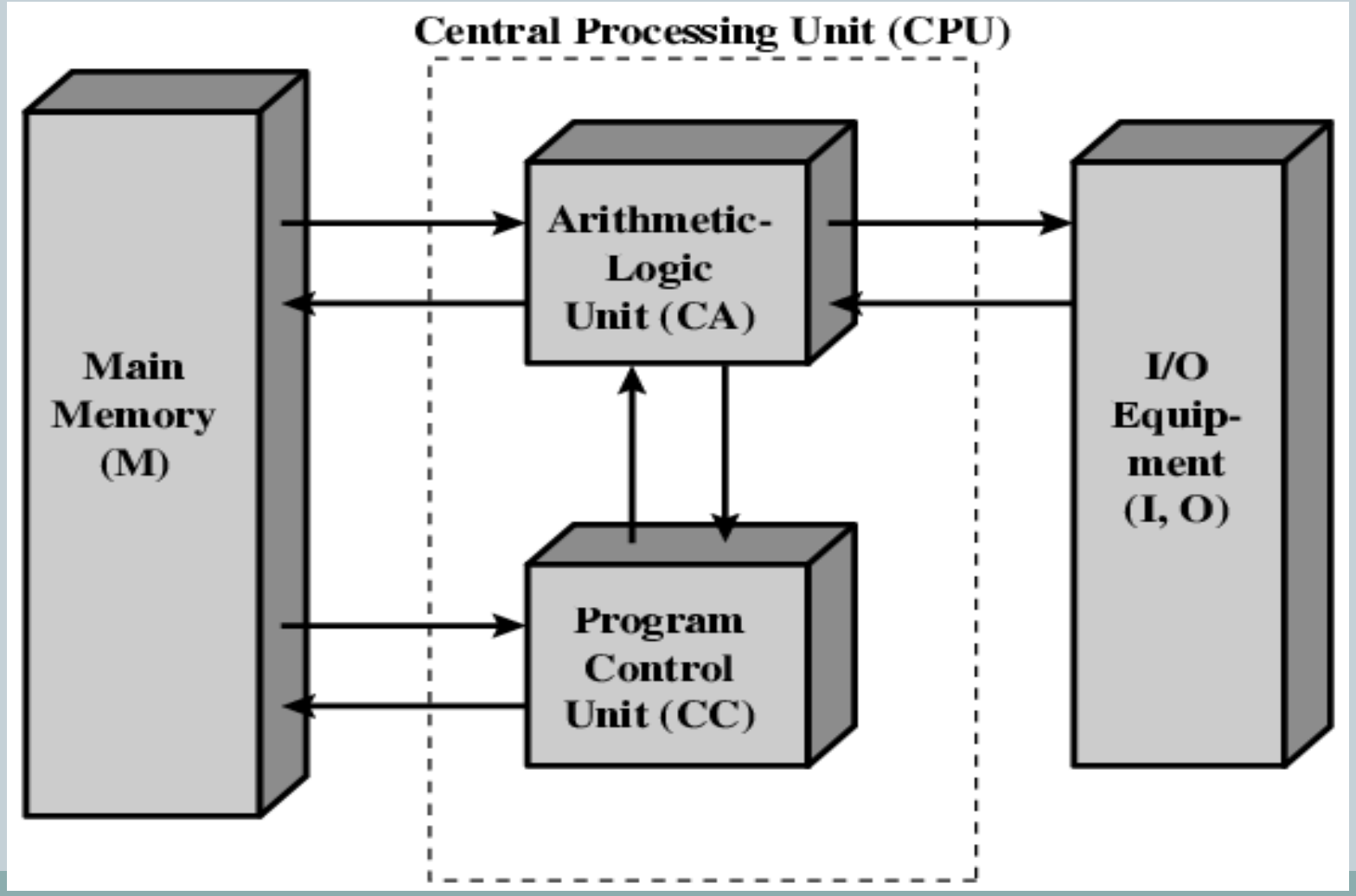
- Programing the ENIAC was extremely tedious.
- But suppose a program could be represented in a form suitable for storing **in memory** alongside the data.
- Then, a computer could get its instructions by reading them from memory, and a program could be set or altered by setting the values of a portion of memory.
- This idea, known as the **stored-program concept**,

Cont'd…

- In 1946, von Neumann the mathematician and his colleagues began the design of a new stored-program computer, referred to as the **IAS** computer, at the Princeton Institute for Advanced Studies.

- All of today's computers have this same general structure and function and are thus referred to as **von Neumann machines.**

Structure of Von Neumann machine



IAS - details

- 1000 x 40 bit words
  - ✓ Binary number
  - ✓ 2 x 20 bit instructions
- Set of registers (**storage in CPU**)
  - ✓ **Memory buffer register (MBR):** Contains a word to be stored in memory or sent to the I/O unit, or is used to receive a word from memory or from the I/O unit.
  - ✓ **Memory address register (MAR):** Specifies the address in memory of the word to be written from or read into the MBR.

Cont'd...

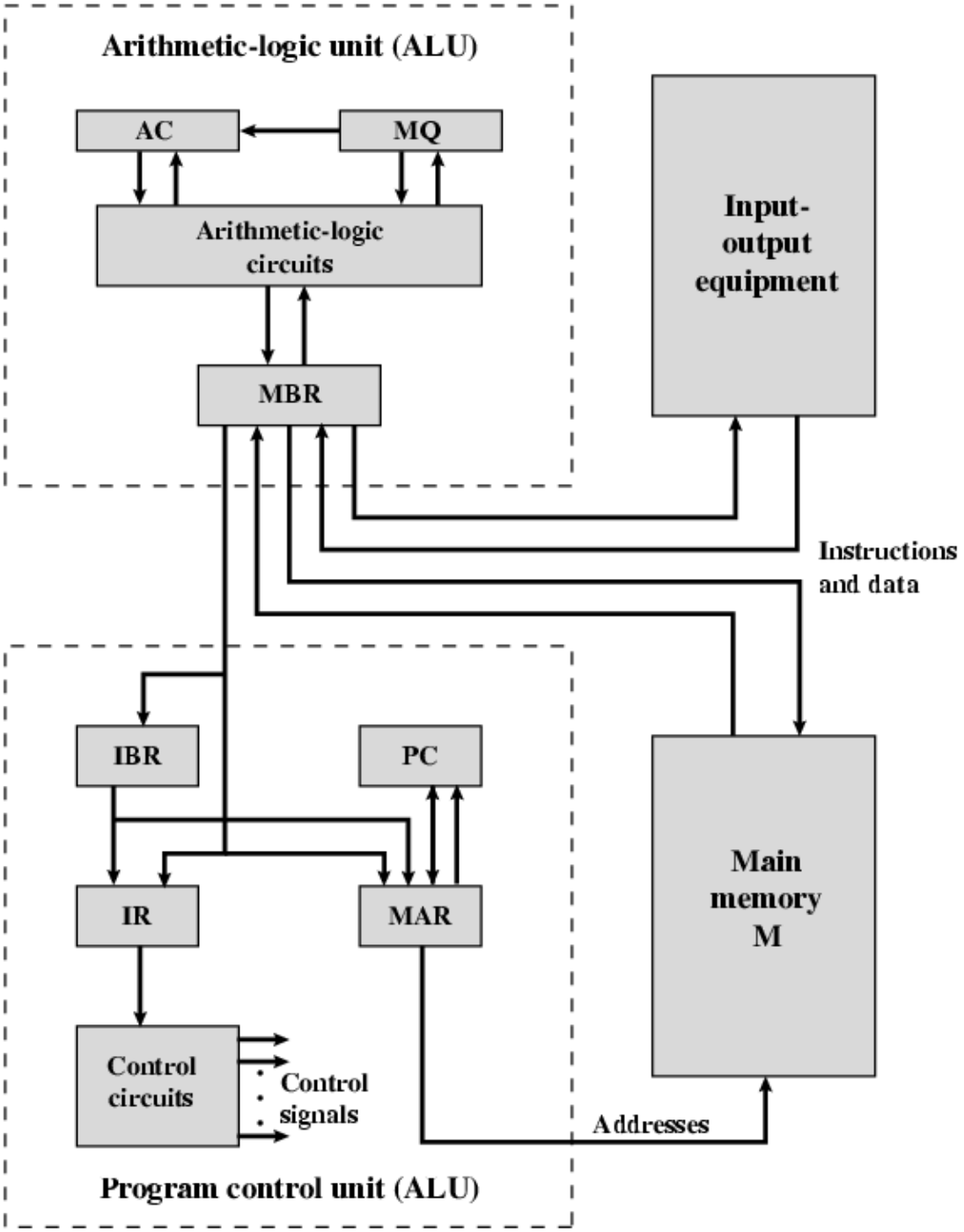
- ✓ **Instruction register (IR):** Contains the 8-bit opcode instruction being executed.
- ✓ **Instruction buffer register (IBR):** Employed to hold temporarily the right hand instruction from a word in memory.
- ✓ **Program counter (PC):** Contains the address of the next instruction pair to be fetched from memory.

Cont'd...

- ✓ **Accumulator (AC) and multiplier quotient (MQ):** Employed to hold temporarily operands and results of ALU operations.

For example, the result of multiplying two 40-bit numbers is an 80-bit number; the most significant 40 bits are stored in the AC and the least significant in the MQ.

Structure of IAS



IBM

- Punched-card processing equipment
- 1953 - the 701
  - ✓ IBM's first stored program computer
  - ✓ Scientific calculations
- Lead to 700/7000 series
- 1955 - the 702: Business applications

The Second Generation: Transistors

- Replaced vacuum tubes
- Smaller
- Cheaper
- Less heat dissipation
- Solid State device
- Made from Silicon (Sand)
- Invented 1947 at Bell Labs
- William Shockley et al.

Cont'd...

- Introduction of more complex arithmetic and logic units and control units,
- The use of high-level programming languages, and
- The provision of *system software* with the computer.

Third Generation: Integrated Circuits

- The separately manufactured components like resistor, capacitor, diode, and transistor are joined by wires or by printed circuit board (PCB) to form circuits. These circuits are called **discrete circuits.**

- An IC comprises a number of circuit components like resistors, transistor etc. They are interconnected **in a single small package** to perform the desired electronic function.

Scale of Integration

- The number of components fitted into a standard size IC represents its integration scale.
- It is classified as: **SSI, MSI, LSI, VLSI, ULSI**

Computer Generations Summary

Generation	Approximate Dates	Technology	Typical Speed (operations per second)
1	1946–1957	Vacuum tube	40,000
2	1958–1964	Transistor	200,000
3	1965–1971	Small- and medium-scale integration	1,000,000
4	1972–1977	Large-scale integration	10,000,000
5	1978–1991	Very-large-scale integration	100,000,000
6	1991–	Ultra-large-scale integration	1,000,000,000

Intel Microprocessors

- 1971 - 4004 *(The microprocessor was born!)*
  - ✓ First microprocessor
  - ✓ All CPU components on a single chip
  - ✓ 4 bit
- Followed in 1972 by 8008
  - ✓ 8 bit
  - ✓ Both designed for specific applications
- 1974 - 8080
  - ✓ Intel's first general purpose microprocessor

Cont'd...

(a) 1970s Processors

	4004	8008	8080	8086	8088
Introduced	1971	1972	1974	1978	1979
Clock speeds	108 kHz	108 kHz	2 MHz	5 MHz, 8 MHz, 10 MHz	5 MHz, 8 MHz
Bus width	4 bits	8 bits	8 bits	16 bits	8 bits
Number of transistors	2300	3500	6000	29,000	29,000
Feature size (µm)	10		6	3	6
Addressable memory	640 Bytes	16 kB	64 kB	1 MB	1 MB

(b) 1980s Processors

	80286	386TM DX	386TM SX	486TM DX CPU
Introduced	1982	1985	1988	1989
Clock speeds	6 MHz–12.5 MHz	16 MHz–33 MHz	16 MHz–33 MHz	25 MHz–50 MHz
Bus width	16 bits	32 bits	16 bits	32 bits
Number of transistors	134,000	275,000	275,000	1.2 million
Feature size (µm)	1.5	1	1	0.8–1
Addressable memory	16 MB	4 GB	16 MB	4 GB
Virtual memory	1 GB	64 TB	64 TB	64 TB
Cache	—	—	—	8 kB

Cont'd...

(c) 1990s Processors

	486TM SX	Pentium	Pentium Pro	Pentium II
Introduced	1991	1993	1995	1997
Clock speeds	16 MHz–33 MHz	60 MHz–166 MHz,	150 MHz–200 MHz	200 MHz–300 MHz
Bus width	32 bits	32 bits	64 bits	64 bits
Number of transistors	1.185 million	3.1 million	5.5 million	7.5 million
Feature size (μm)	1	0.8	0.6	0.35
Addressable memory	4 GB	4 GB	64 GB	64 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB
Cache	8 kB	8 kB	512 kB L1 and 1 MB L2	512 kB L2

(d) Recent Processors

	Pentium III	Pentium 4	Core 2 Duo	Core i7 EE 990
Introduced	1999	2000	2006	2011
Clock speeds	450–660 MHz	1.3–1.8 GHz	1.06–1.2 GHz	3.5 GHz
Bus width	64 bits	64 bits	64 bits	64 bits
Number of transistors	9.5 million	42 million	167 million	1170 million
Feature size (nm)	250	180	65	32
Addressable memory	64 GB	64 GB	64 GB	64 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB
Cache	512 kB L2	256 kB L2	2 MB L2	1.5 MB L2/12 MB L3

Multicore

- Multiple processors on single chip
  - ✓ Large shared cache
- Within a processor, increase in performance proportional to square root of increase in complexity
- If software can use multiple processors, doubling number of processors almost doubles performance
- So, use two simpler processors on the chip rather than one more complex processor
- With two processors, larger caches are justified
  - ✓ Power consumption of memory logic less than processing logic

The two well known processor families

- **Intel x86 architecture:** The x86 architecture is the most widely used for *non-embedded* computer systems. The x86 is essentially a complex instruction set computer (**CISC**).

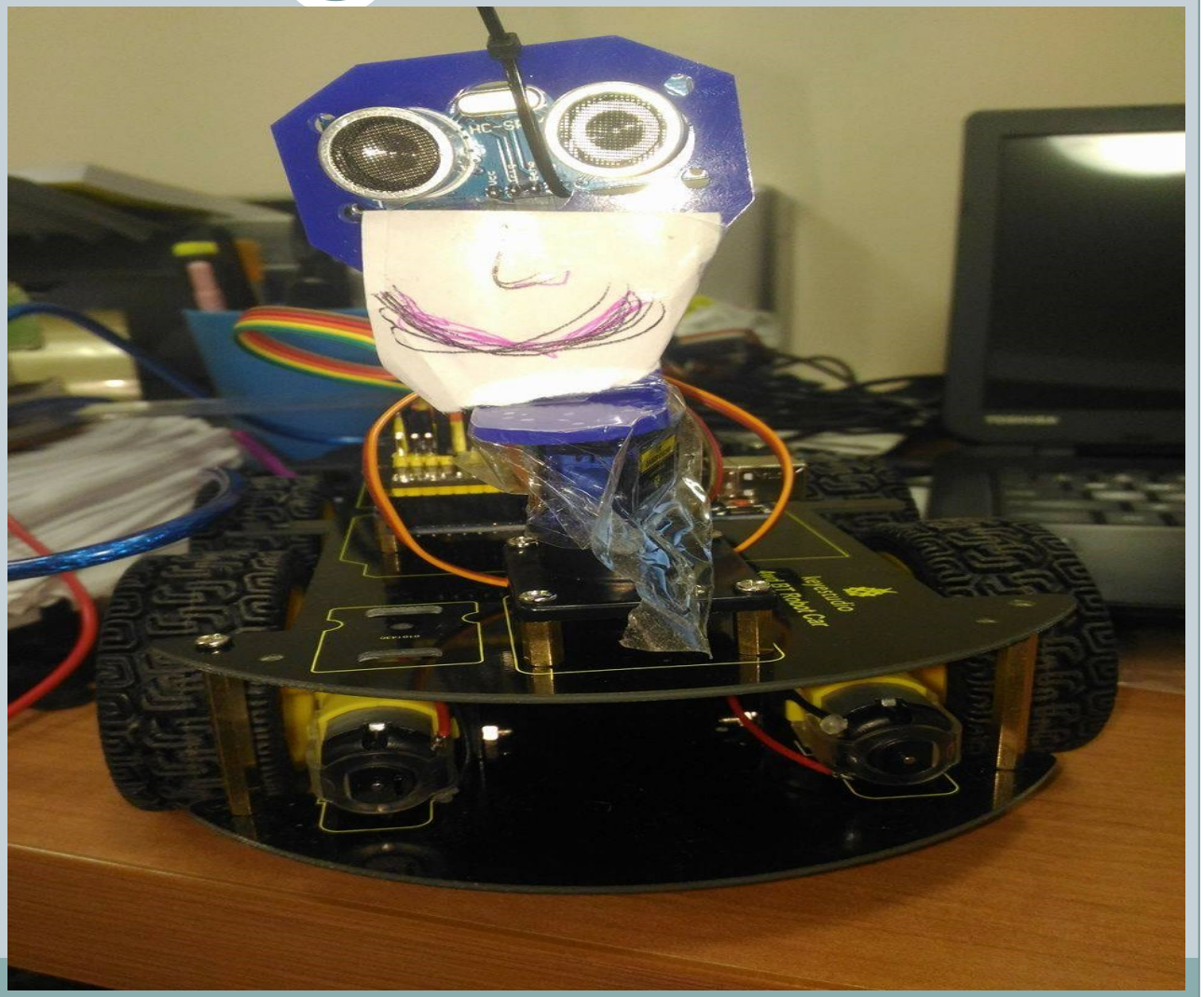
- **ARM:** The ARM architecture is arguably the most widely used embedded processor, used in cell phones, iPods, remote sensor equipment, and many other devices. ARM is essentially a reduced instruction set computer (**RISC**).

Embedded Systems ARM

- ARM evolved from RISC design
- Used mainly in embedded systems
  - ✓Used within product
  - ✓Not general purpose computer
  - ✓Dedicated function
  - ✓E.g. **Anti-lock brakes** in car

Sample Embedded system

Collision Avoidance robot



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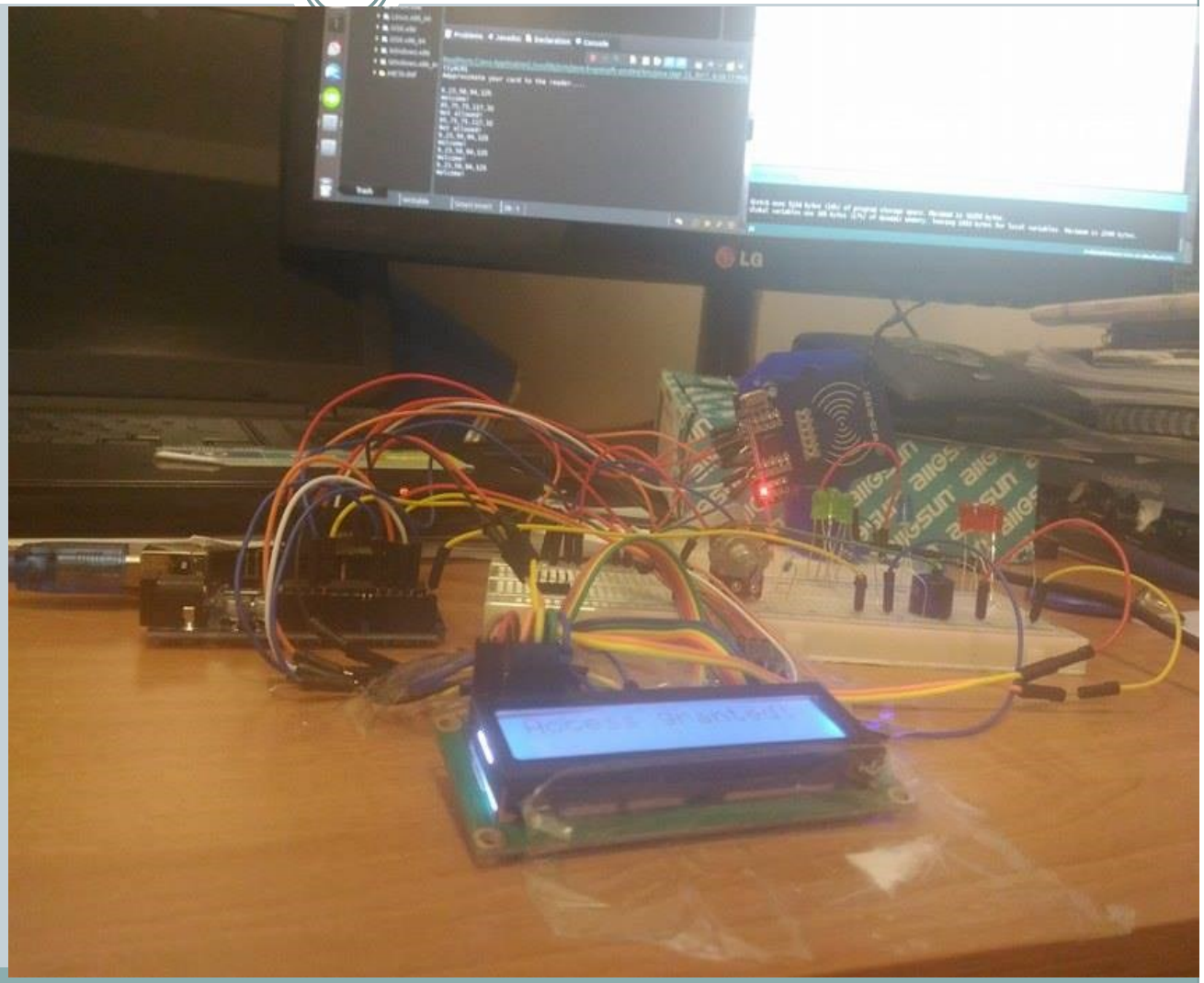
Final Projects ECE 4760
LG
4WD Bluetooth
Multi-functional Car Kit
Сады Придонья

Cont'd…

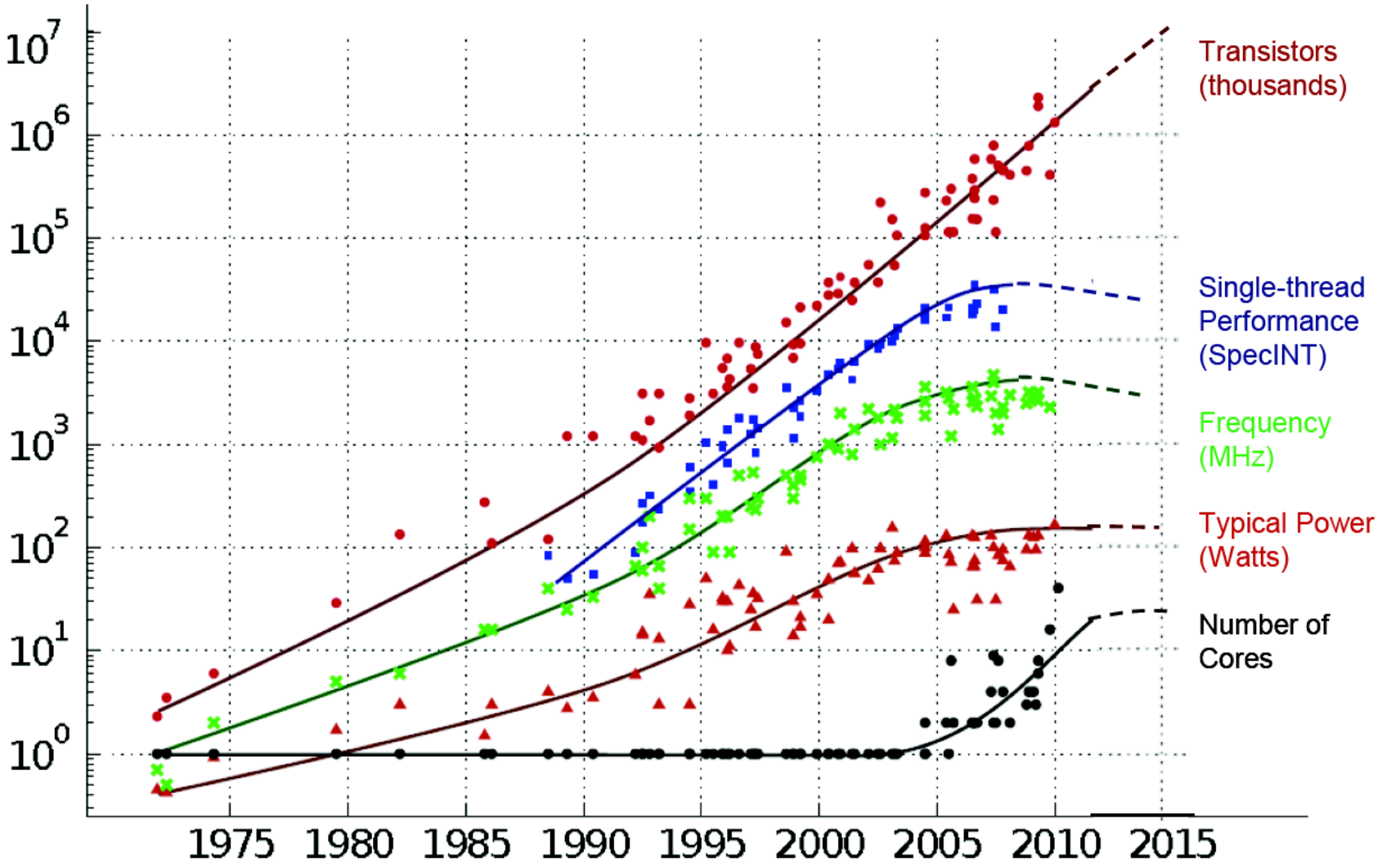
- Sensors
- Analog to digital conversion
- Processor
- Programming



Moore's Law

- Increased density of components on chip
- Gordon Moore – co-founder of Intel
- Number of transistors on a chip will double every year
- Since 1970's development has slowed a little
  Number of transistors doubles every 18 months
- Cost of a chip has remained almost unchanged
- Higher packing density means shorter electrical paths, giving higher performance
- Smaller size gives increased flexibility
- Reduced power and cooling requirements
- Fewer interconnections increases reliability

35 YEARS OF MICROPROCESSOR TREND DATA



Original data collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond and C. Batten
Dotted line extrapolations by C. Moore

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ARM
ARMv8-A
Platform
ARM® Cortex®-A57 MP2 r0p0
Cortex-A53 MP4 r0p0
ARM Mali™-T624 MP4 r0p1
CoreSight™ & CoreLink™ 400
ARM SBSA L1, CBSA L1, TBSA 1
ARM Cortex-M3
ARM Artisan®, POP™ IP
TSMC 28HPM
T6B109.00 W3 032 (TTTT)
2714 1143
TRACE
DUAL
R010
R010

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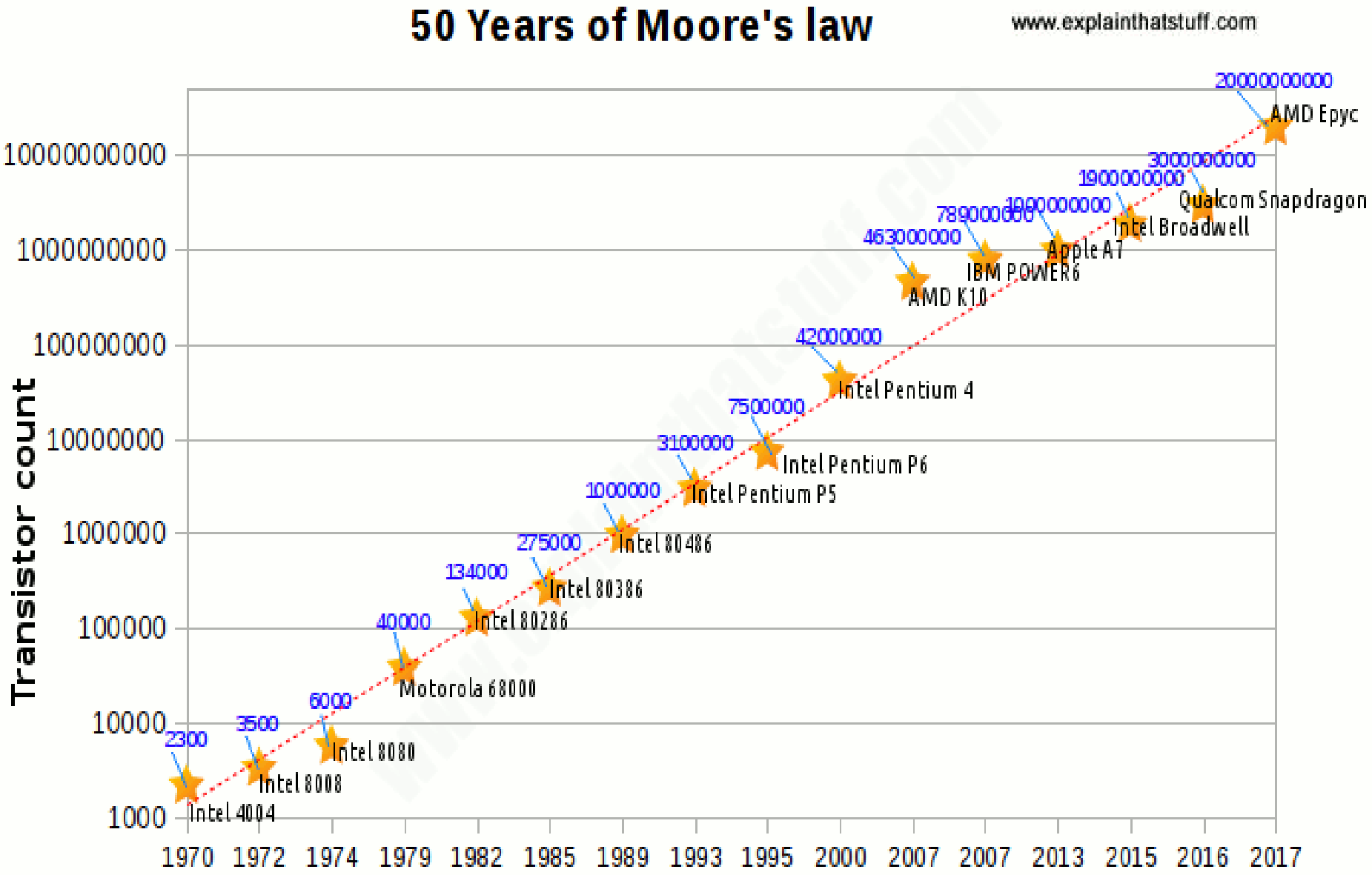
50 Years of Moore's law
www.explainthatstuff.com
Transistor count
10000000000
1000000000
100000000
10000000
1000000
100000
10000
1000
1970
1972
1974
1979
1982
1985
1989
1993
1995
2000
2007
2007
2013
2015
2016
2017
2300
Intel 4004
3500
Intel 8008
6000
Intel 8080
40000
Motorola 68000
134000
Intel 80286
275000
Intel 80386
1000000
Intel 80486
3100000
Intel Pentium P5
7500000
Intel Pentium P6
42000000
Intel Pentium 4
463000000
AMD K10
789000000
IBM POWER6
1900000000
Apple A7
1900000000
Intel Broadwell
3000000000
Qualcom Snapdragon
20000000000
AMD Epyc

Questions?

Next Lecture

Chapter Two
Part-2

Performance Assessment