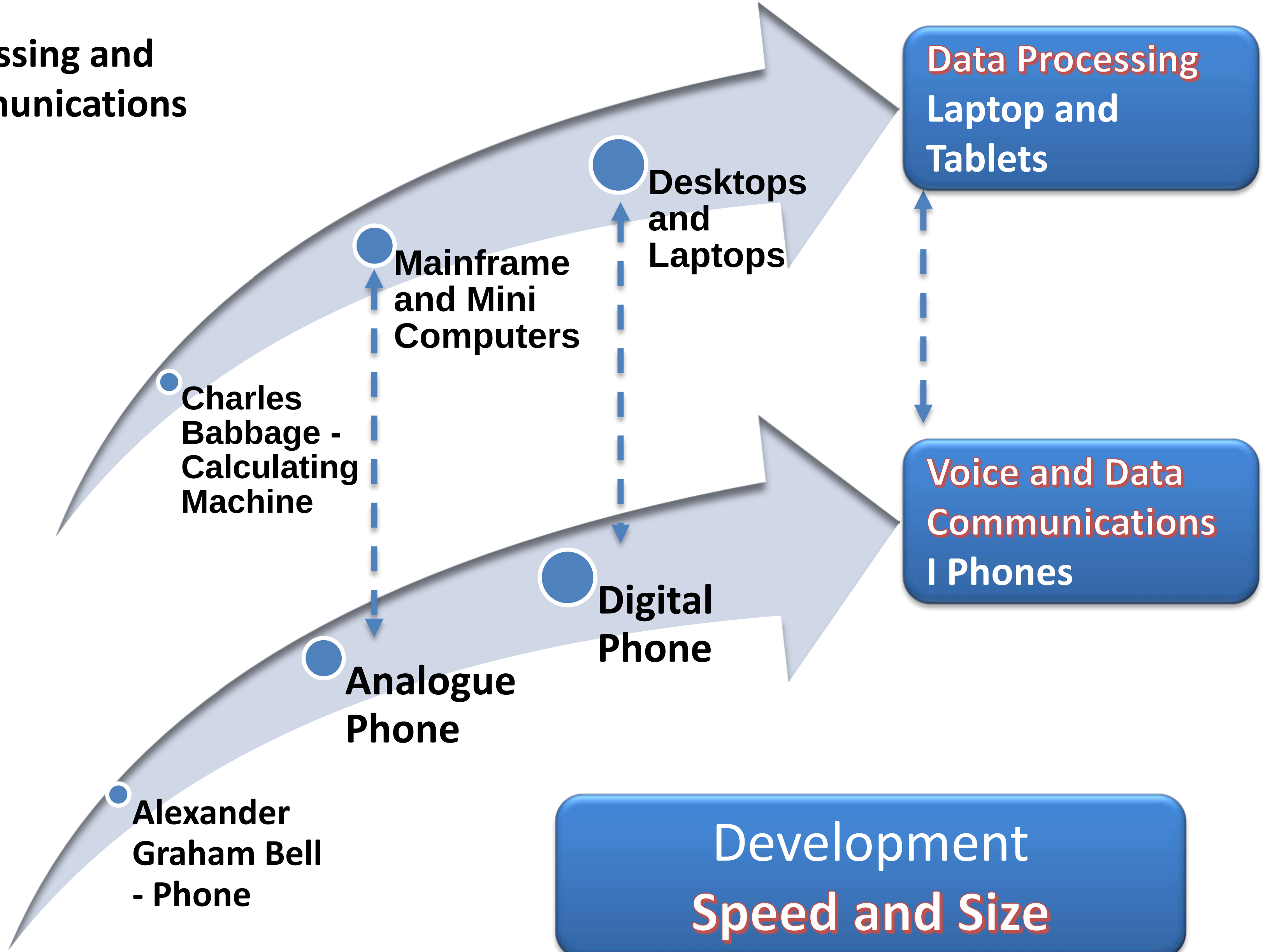
Bits, Nibbles and Bytes

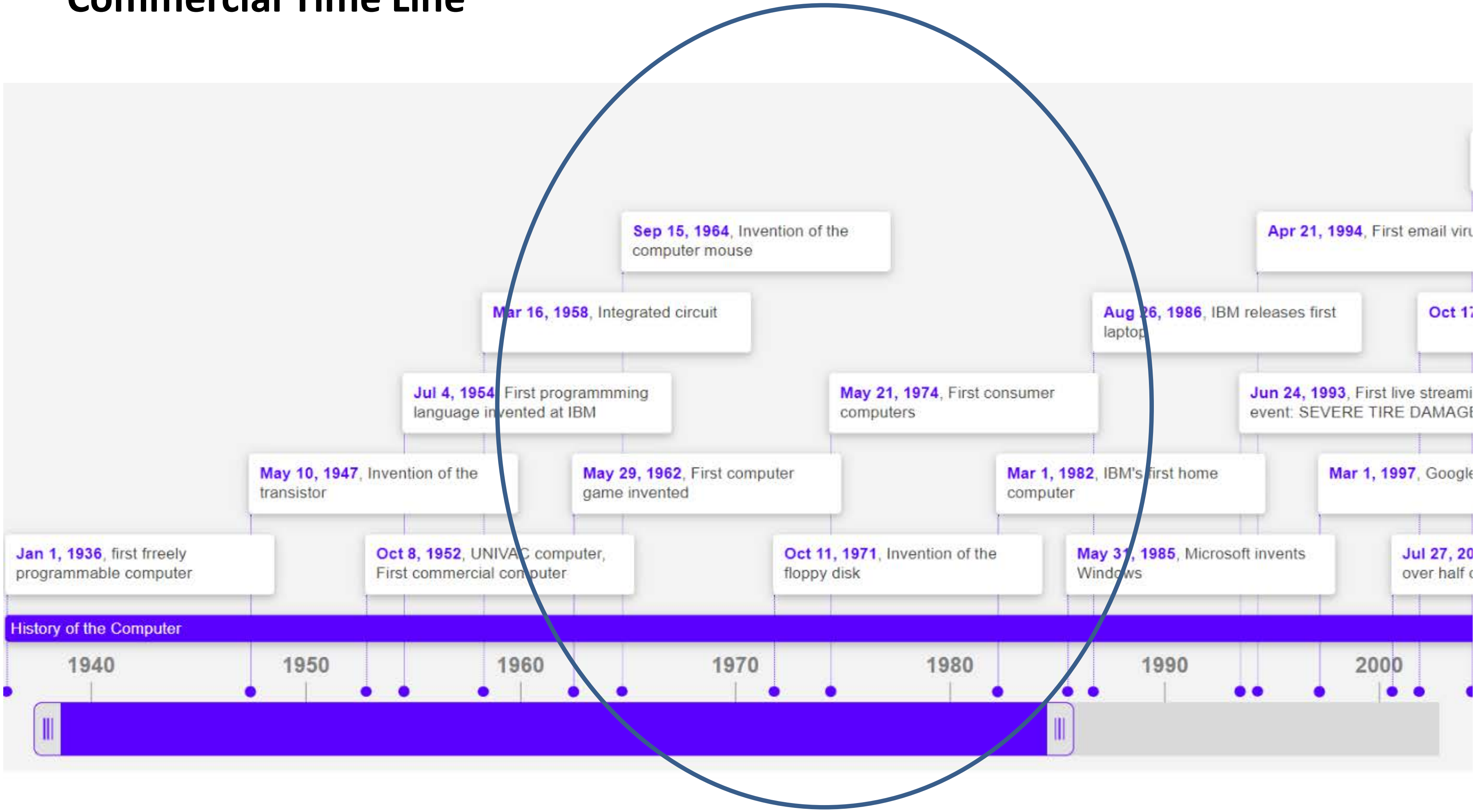
August 15th 2022

u3a Computer Club

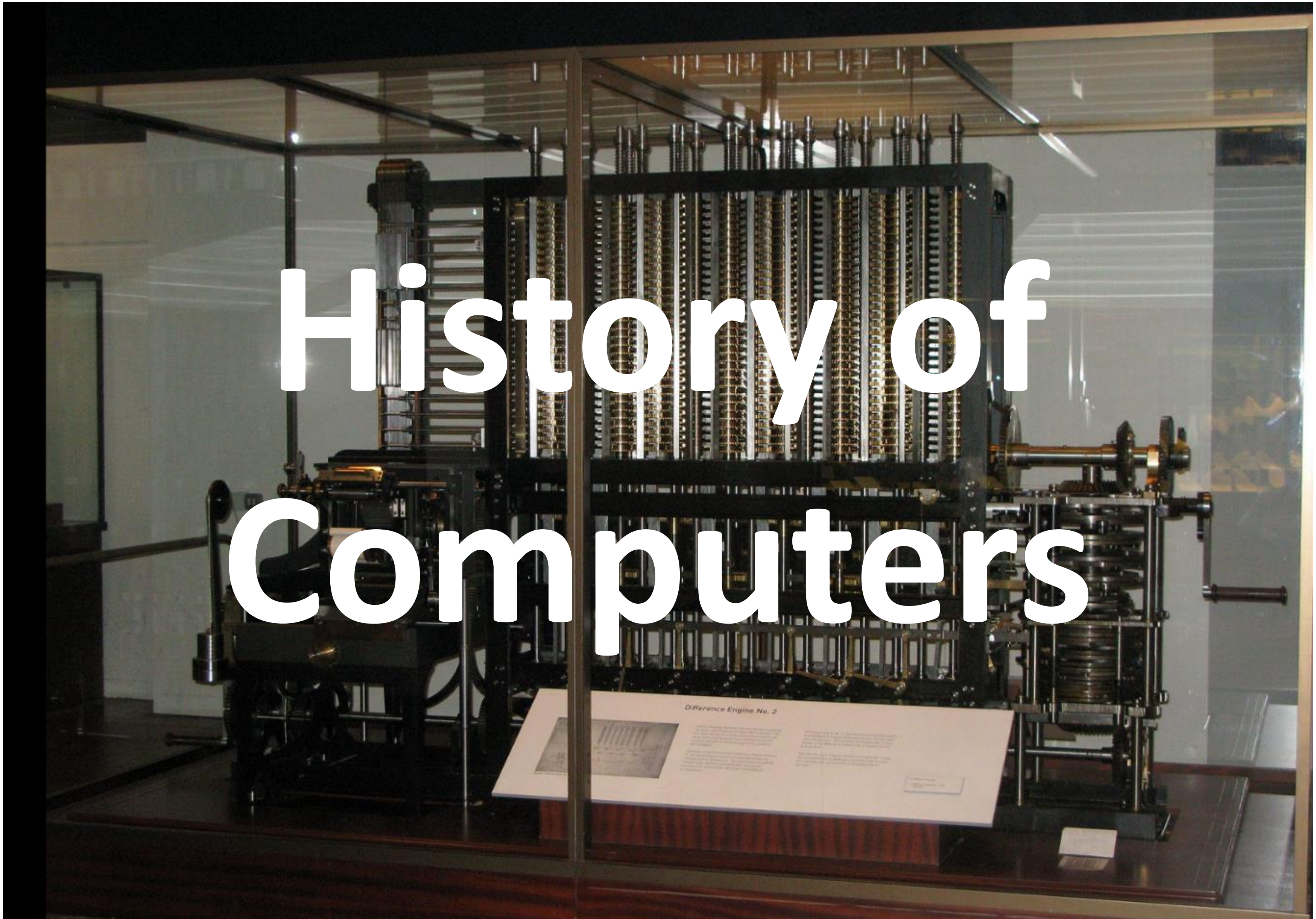
Processing and Communications



Commercial Time Line



History of Computers



Types of Computers

Analog Computers

Analog computers are built with various components such as gears and levers, with no electrical components. One advantage of analogue computation is that designing and building an analogue computer to tackle a specific problem can be quite straightforward.

Digital Computers

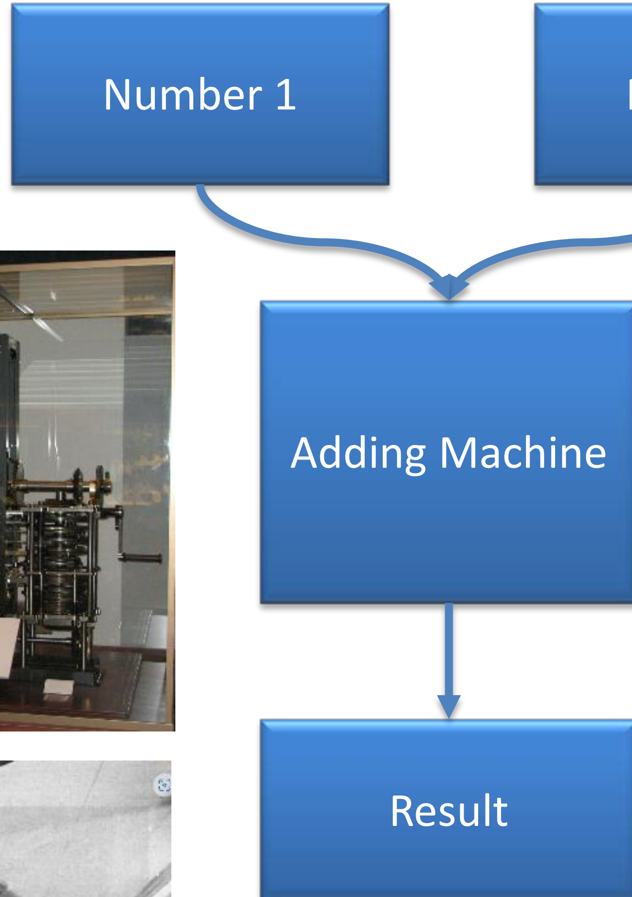
Information in digital computers is represented in discrete form, typically as sequences of 0s and 1s (binary digits, or bits). A digital computer is a system or gadget that can process any type of information in a matter of seconds. Digital computers are categorized into many different types. They are as follows:

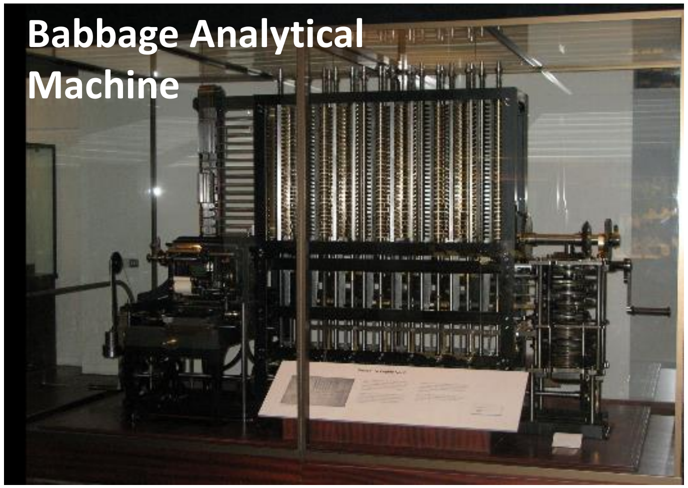
1. Mainframe computers
2. Supercomputers
3. Minicomputers
4. Microcomputers
5. Embedded processors

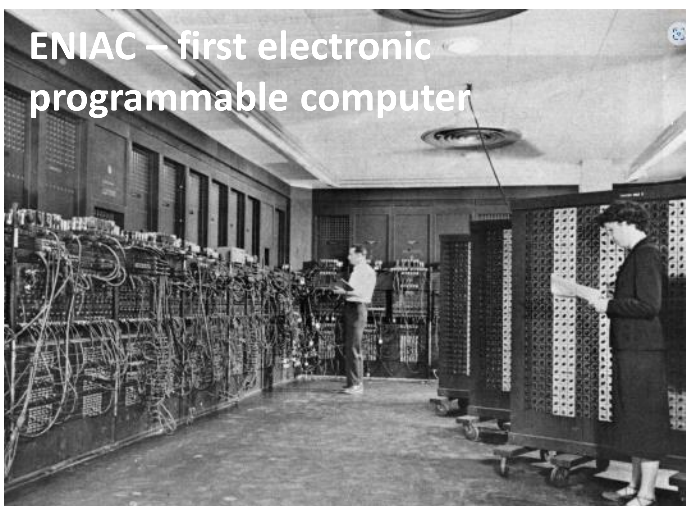
Charles Babbage calculating machine
Science Museum London

Digital Equipment Company pdp8

The Adding Machine







Heart of the Computer - Addition

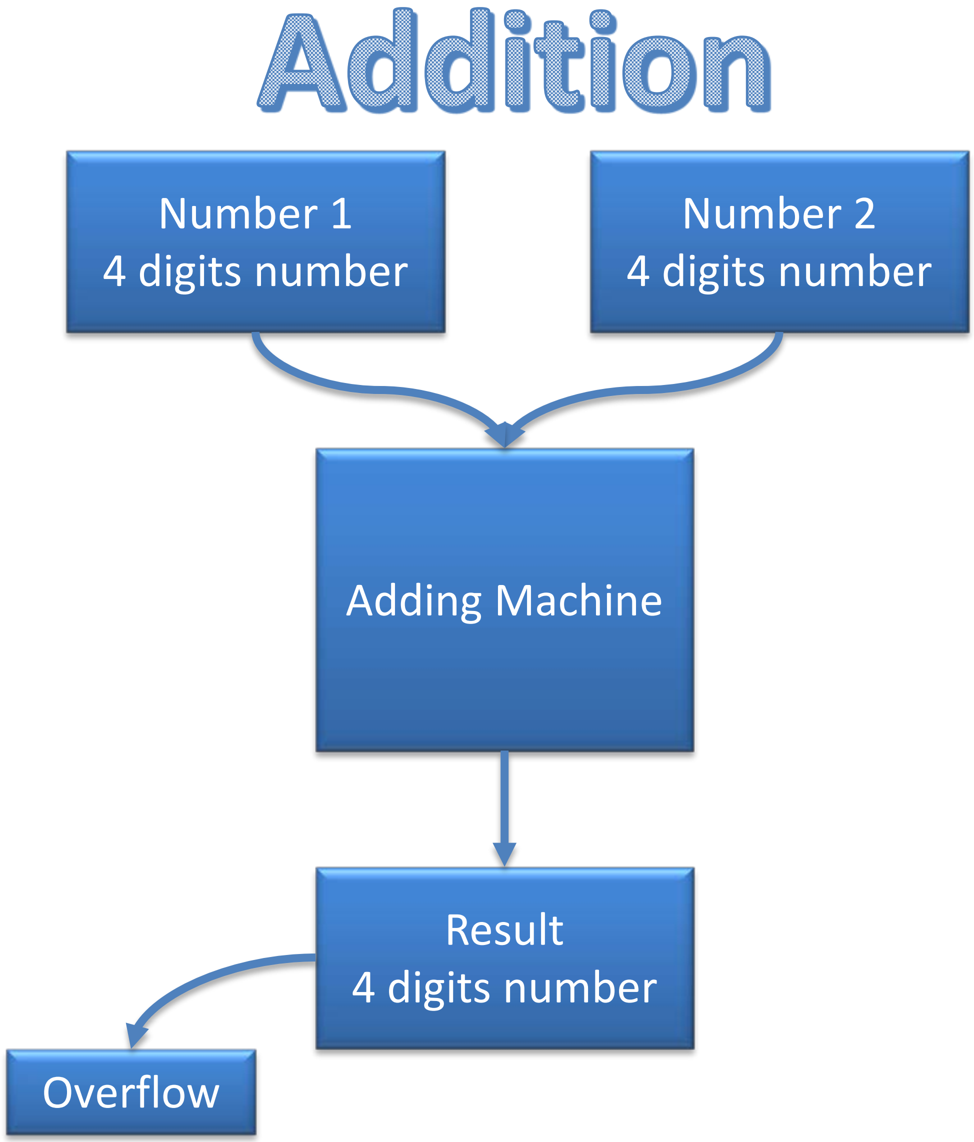
Example shows two 4 digit number being added together. The result is a 4 digit number with an overflow.

<u>Example 1</u>

0147 + 4367 = 4514

<u>Example 2</u>

8147 + 4367 = 2514 with an overflow of 1



Subtraction

Heart of the Computer - Subtracting

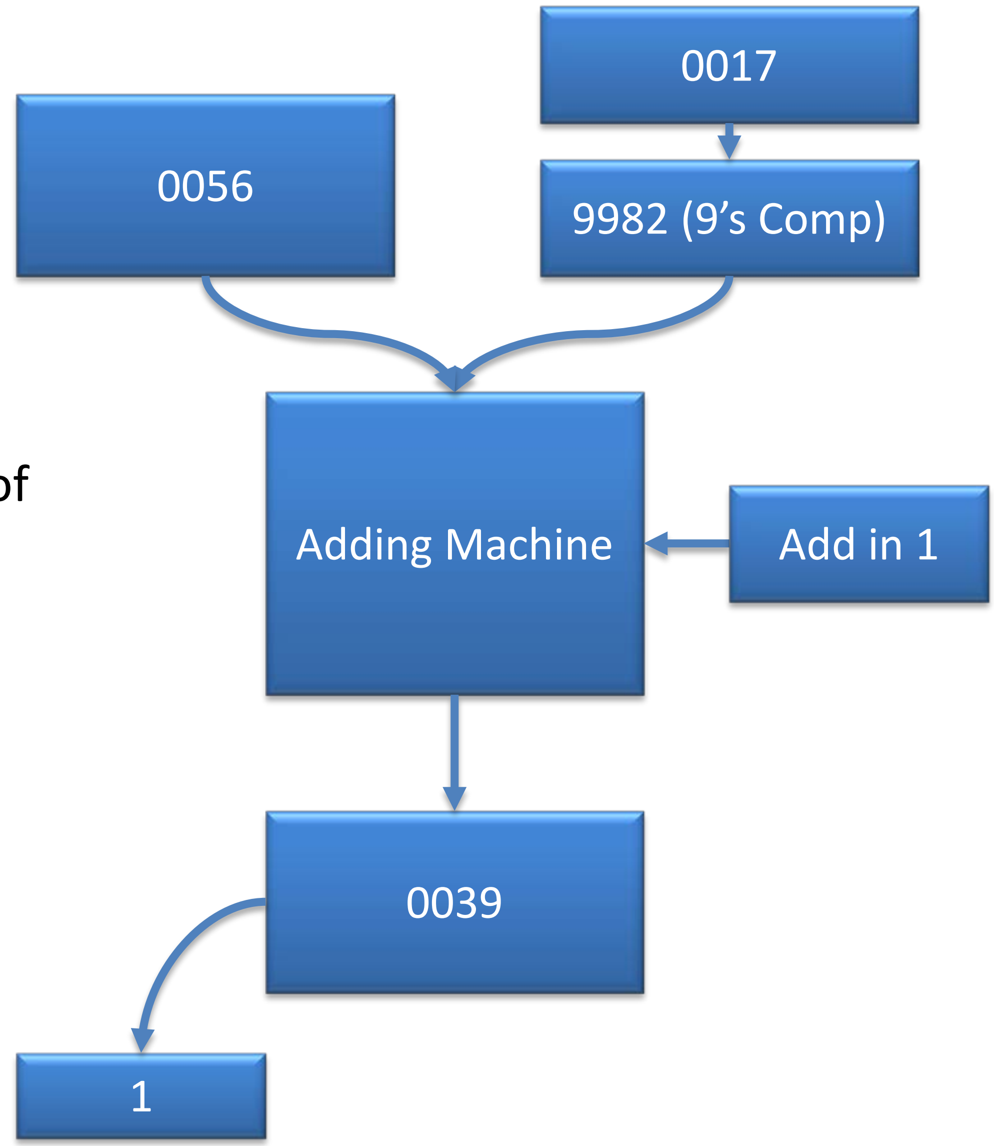
Subtraction is achieved by adding the “invert” of the negative number and add 1.

For the “invert” of a decimal numbers we take the 9’s complement and for the “invert” of a binary numbers we take the 2’s complement.

<u>Example 1 (56 - 17)</u>

0056 - 0017

0056 + 9982 (9’s Complement) = 0038 + 1 (with overflow of 1) = 39



Heart of the Computer - Subtracting

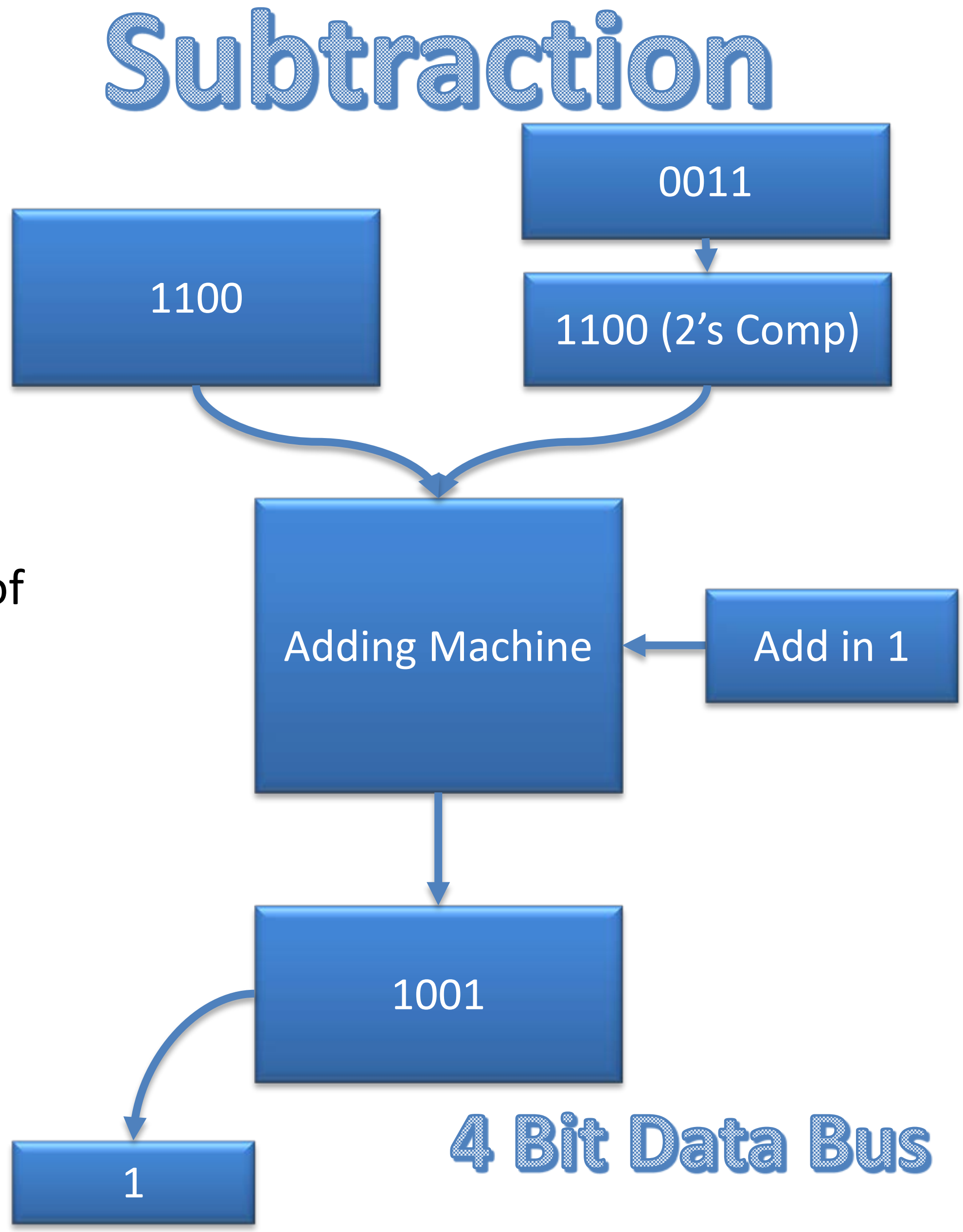
Subtraction is achieved by adding the “invert” of the negative number and add 1.

For the “invert” of a decimal numbers we take the 9’s complement and for the “invert” of a binary numbers we take the 2’s complement.

<u>Example 2 (1100 - 011) (dec 12 - 3)</u>

1100 - 0011

1100 + 1100 (2’s Complement) = 1000 + 1 (with overflow of 1) = 9



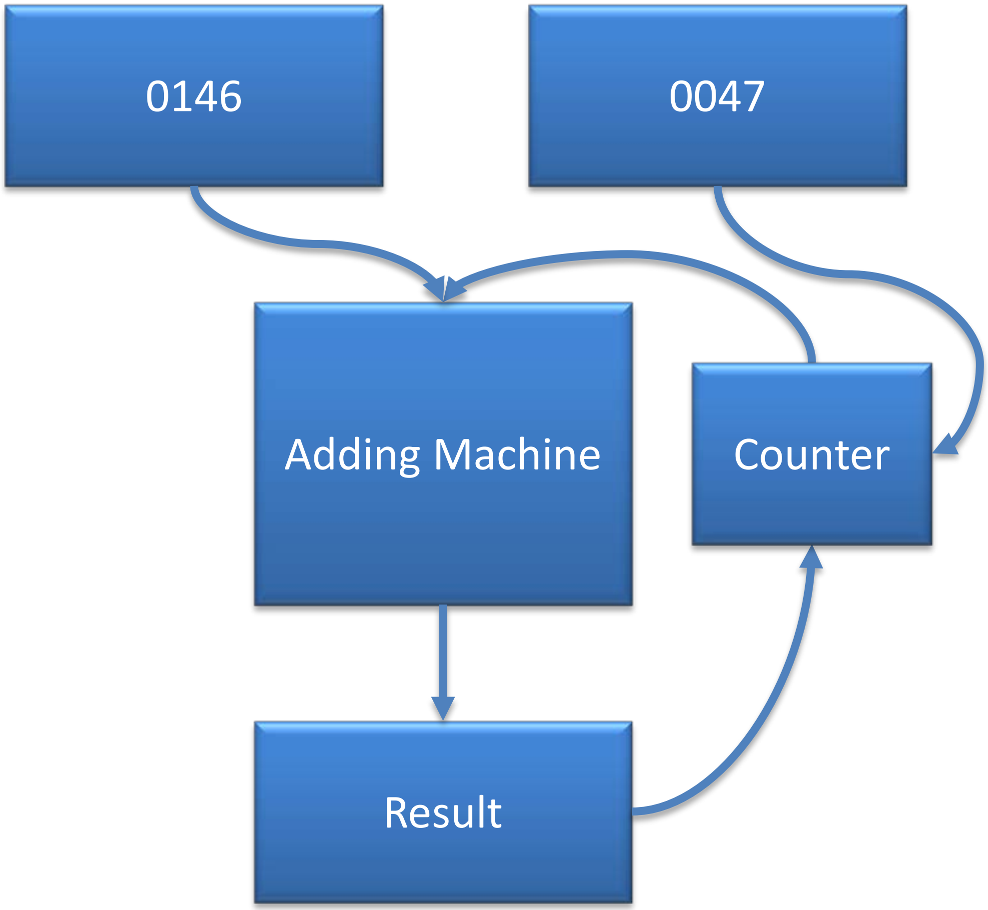
Multiplication

Heart of the Computer - Multiplication

Multiplication is achieved by adding the first number to itself a number of times as defined by the second number i.e. 6 x 4 = 6 + 6 + 6 + 6 = 24

Example 1

146 x 47 = 6862



Division

Heart of the Computer - Division

Division is achieved by counting the number of times you can subtract the second number from the first number

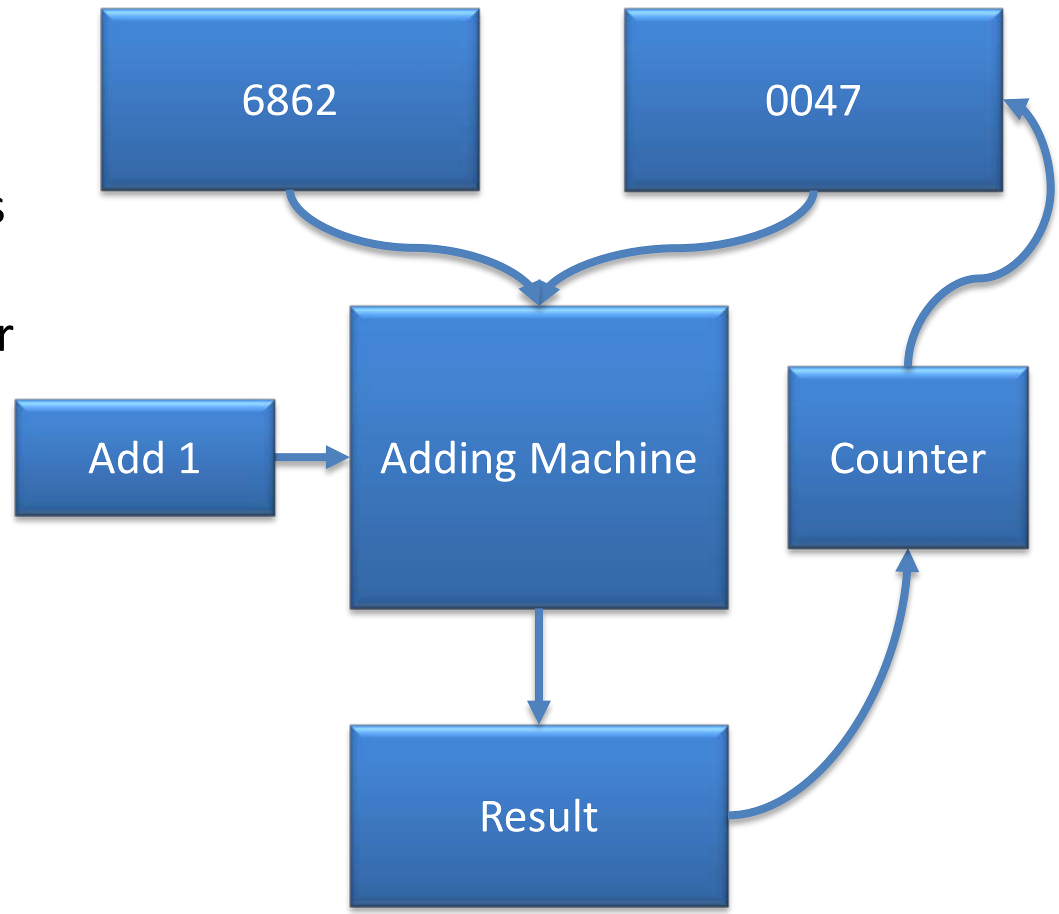
i.e. 9/3 = 9 - 3 = 6   i.e. 1

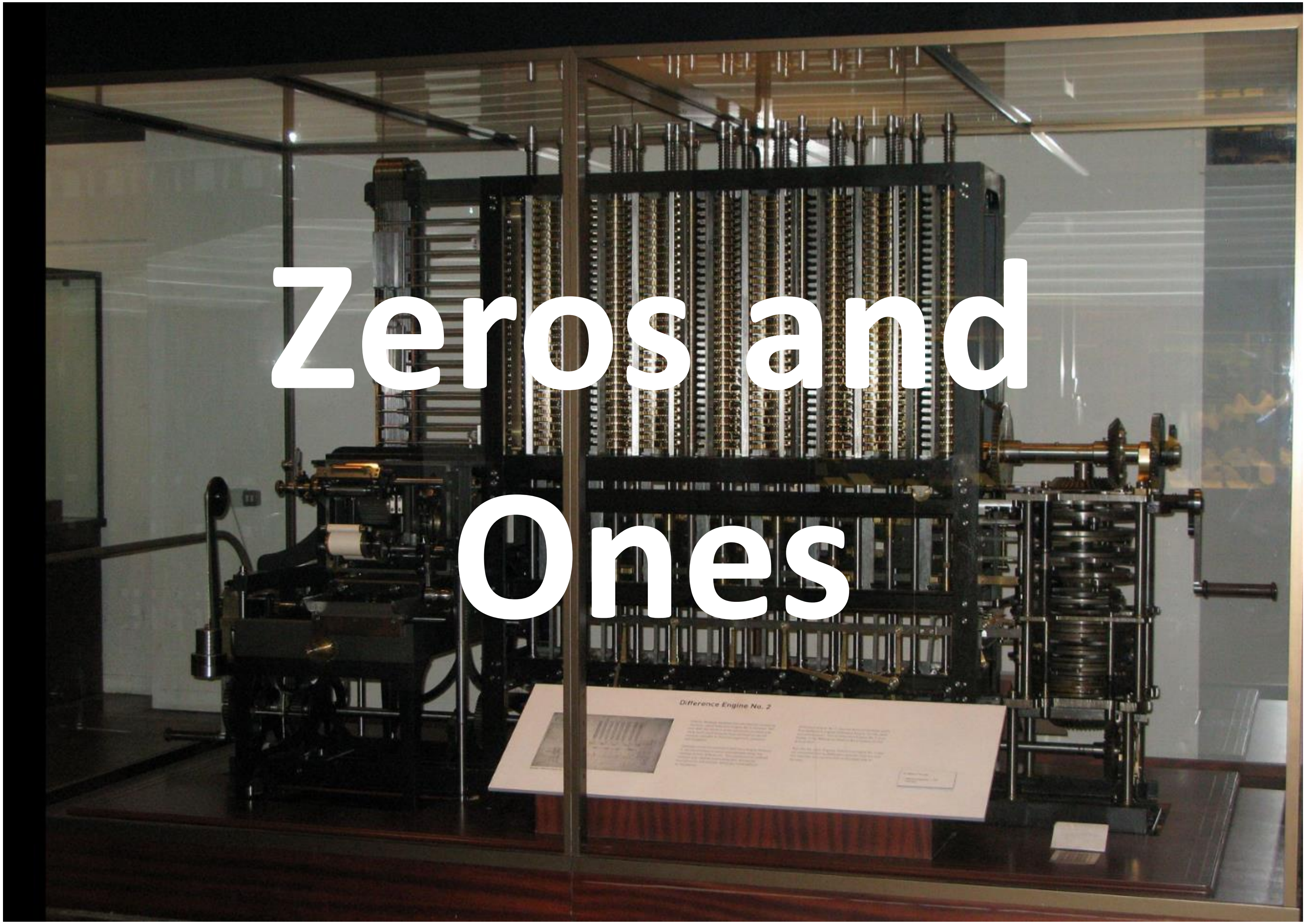
6 - 3 = 3   i.e. 2

3 - 3 = 0   i.e. 3

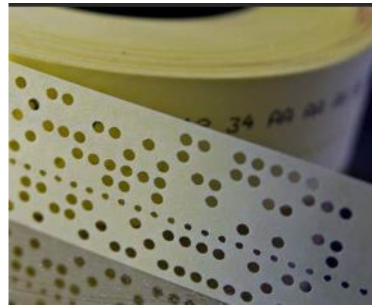
Example 1

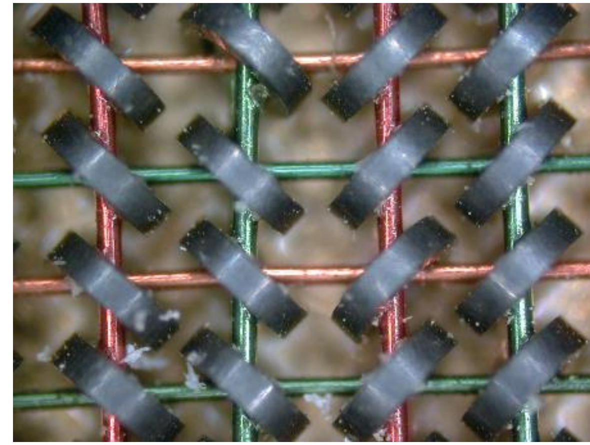
6862/0047 = 0146




Zeros and
Ones
Difference Engine No. 2

Early Technology

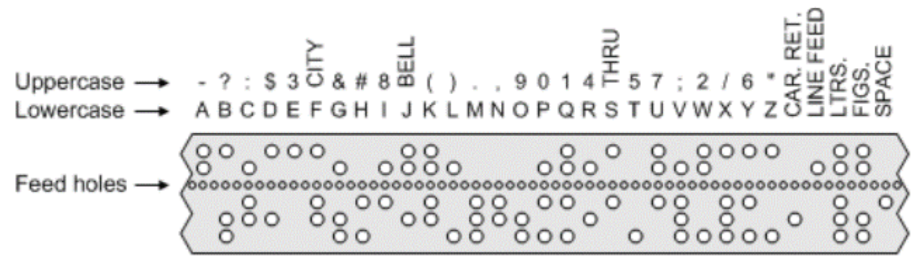




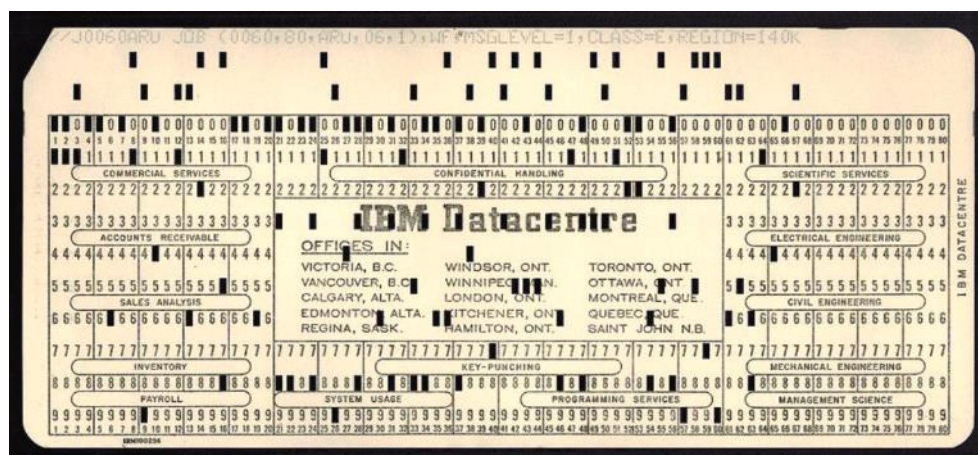
Computers don't understand words or numbers the way humans do. Modern software allows the end user to ignore this, but at the lowest levels of your computer, everything is represented by a binary electrical signal that registers in one of two states: on or off. To make sense of complicated data, your computer has to encode it in binary.

So why do computers use binary? The short answer is that every number in your computer is an electrical signal, and in the early days of computing, electrical signals were much harder to measure and control very precisely. It made more sense to only distinguish between an "on" state—represented by negative charge—and an "off" state—represented by a positive charge. For those unsure of why the "off" is represented by a positive charge, it's because electrons have a negative charge—more electrons mean more current with a negative charge.

So, the early room-sized computers used binary to build their systems, and even though they used much older, bulkier hardware, we've kept the same fundamental principles. Modern computers use what's known as a transistor to perform calculations with binary.



Paper tape showing the five-bit Baudot Code



Counting in Decimal and Binary

Decimal number 1435 =

1000 + 400 + 30 +5

Binary number 13 =

8 + 4 + 1

Decimal Number	Binary Number	Decimal Number	Binary Number	Decimal Number	Binary Number
0	0	10	1010	20	10100
1	1	11	1011	21	10101
2	10	12	1100	22	10110
3	11	13	1101	23	10111
4	100	14	1110	24	11000
5	101	15	1111	25	11001
6	110	16	10000	26	11010
7	111	17	10001	27	11011
8	1000	18	10010	28	11100
9	1001	19	10011	29	11101

	Thousands	Hundreds	Tens	Ones
Decimal	10^3	10^2	10^1	10^0
Dec - 1435	1	4	3	5
Binary	2^3	2^2	2^1	2^0
Binary - 13	1	1	0	1

Bits and Bytes

Computers use binary, the digits 0 and 1, to store data. A binary digit, or bit, is the smallest unit of data in computing. It is represented by a 0 or a 1.

Binary numbers are made up of binary digits (bits), e.g. the binary number 1001 = 9.

- To convert numbers into binary, we need 10 binary codes (0-9) i.e. 3 bits.
- To convert alpha characters into binary, we need 26 (or 52 for upper and lower case) binary codes i.e. 3 bits.
- A-Z needs 26 binary numbers i.e. 5 bits
- 0-9 and A-Z needs 36 binary numbers i.e. 7 bits
- If you have to include other characters i.e. (-=.,/ etc.) i.e. 8 bits or 1 byte

Terminology

Bit – Binary Digit (0 or 1)

4 Bits = 1 Nibble

2 Nibbles = 1 Byte

or 8 Bits = 1 Byte

1 Word = 4, 8, 12, 16, 32 etc., up to 64 Bits

Bits and Bytes

Terminology

- Bit – Binary Digit (0 or 1)
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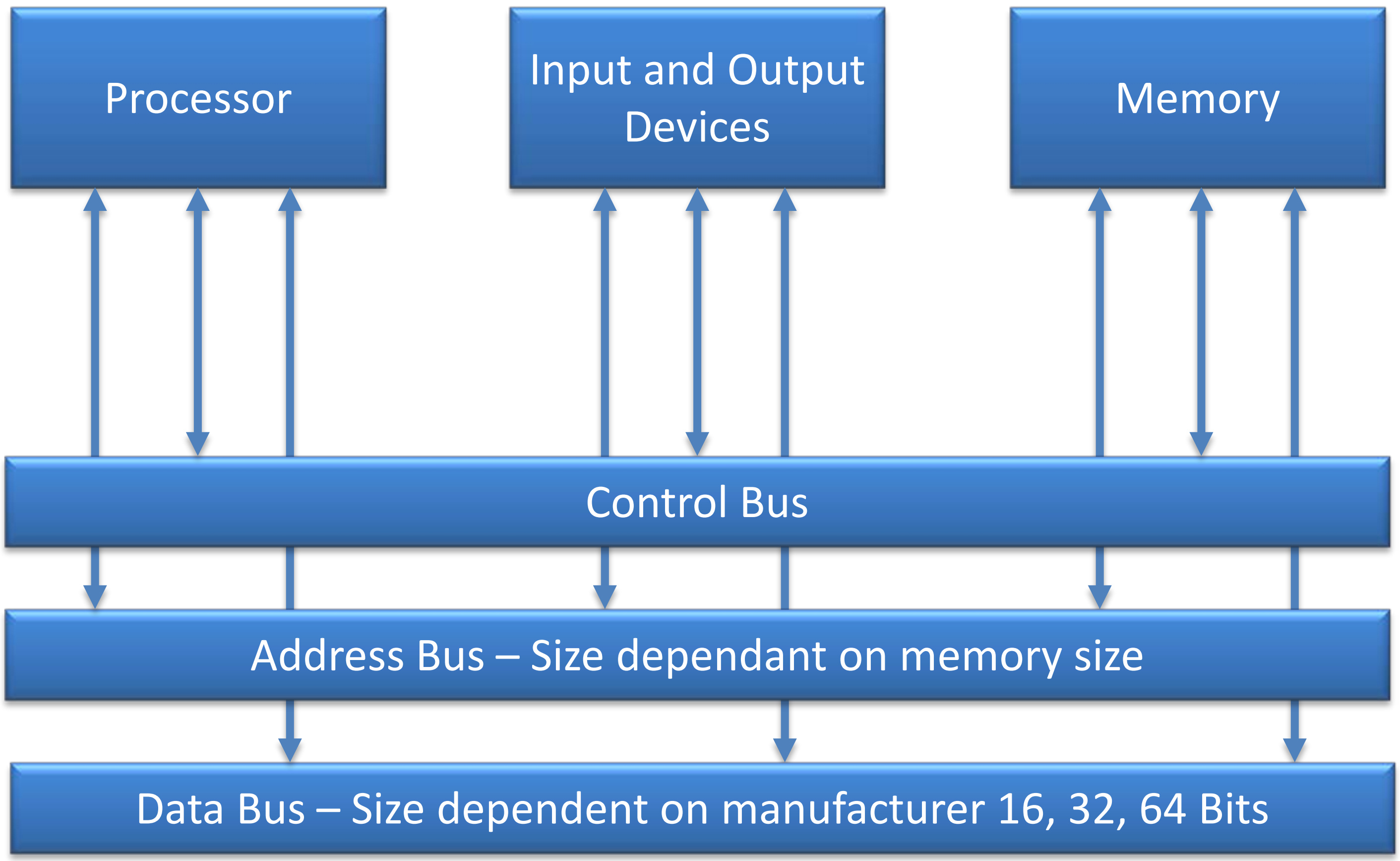
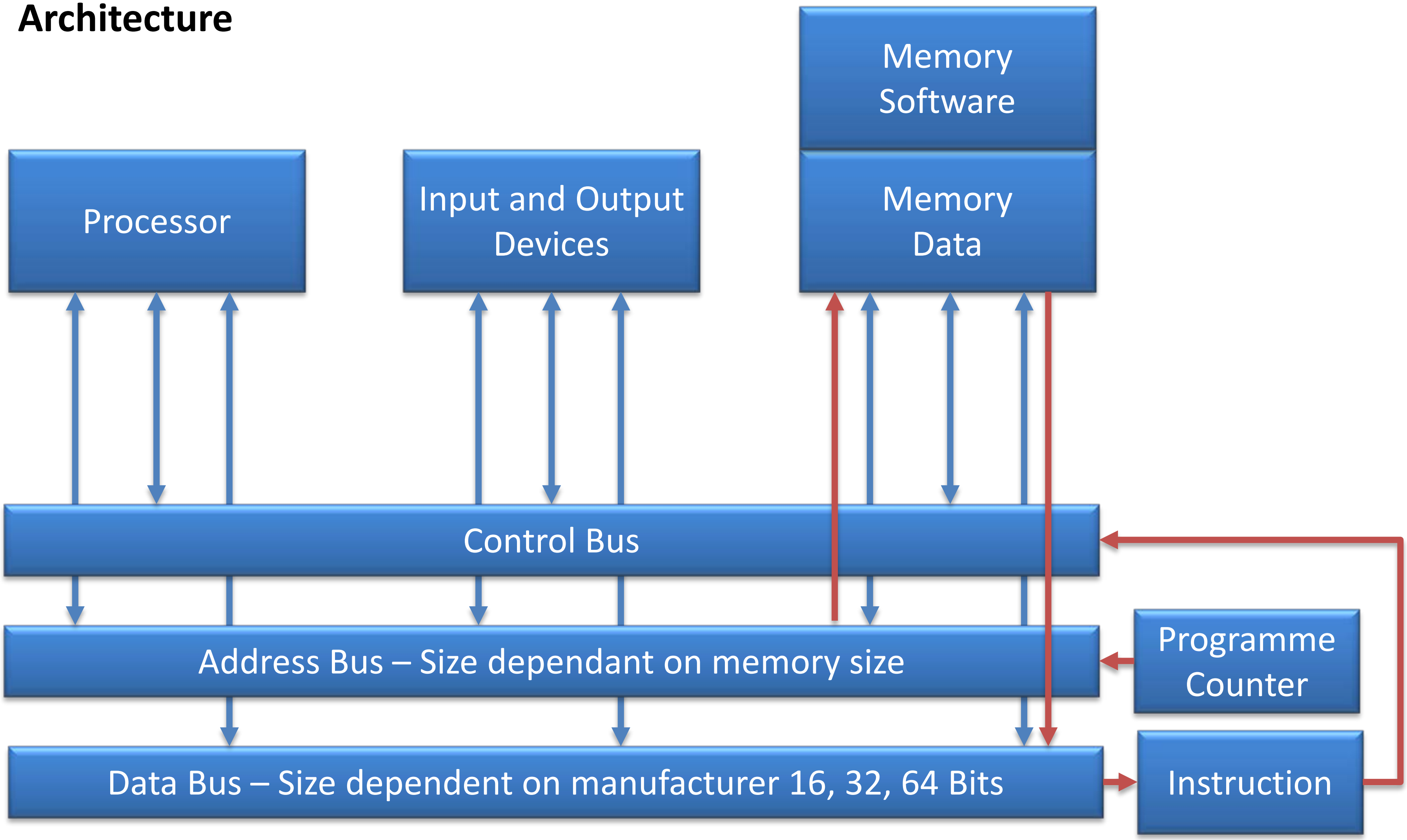
- 2 Nibbles = 1 Byte
- or 8 Bits = 1 Byte
- 1 Word = 4, 8, 12, 16, 32 etc., up to 64 Bits

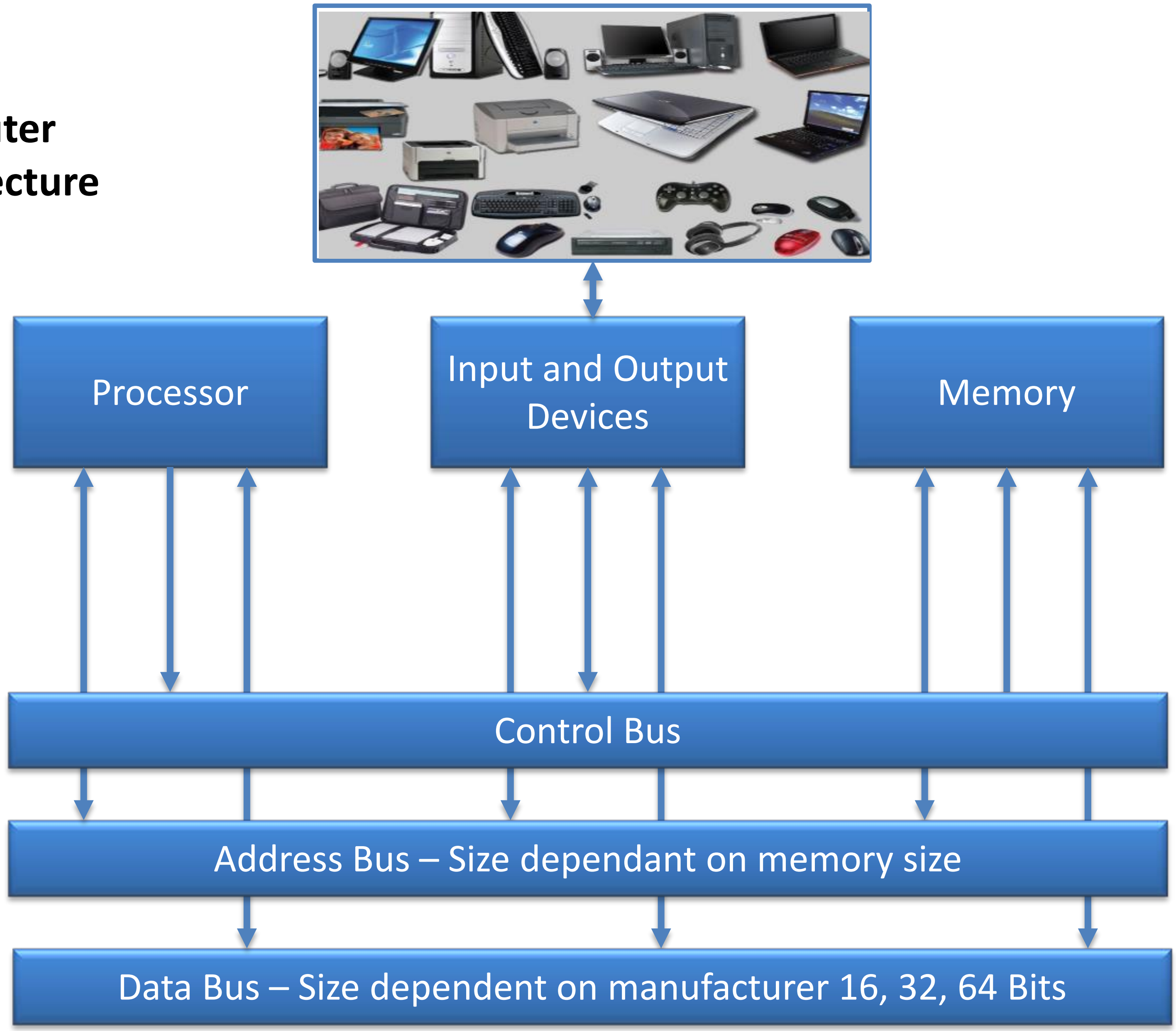
Computer Architecture



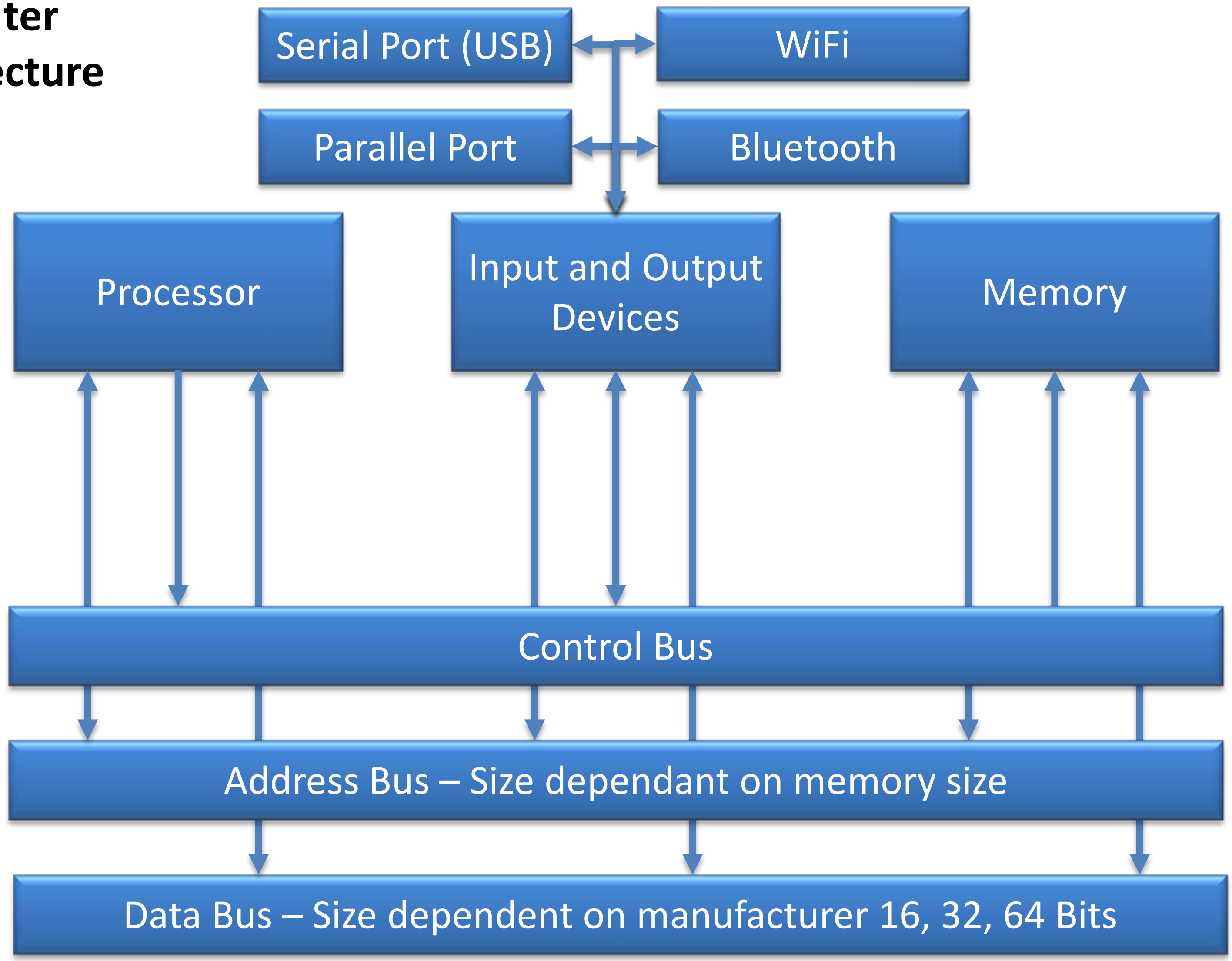
Computer Architecture



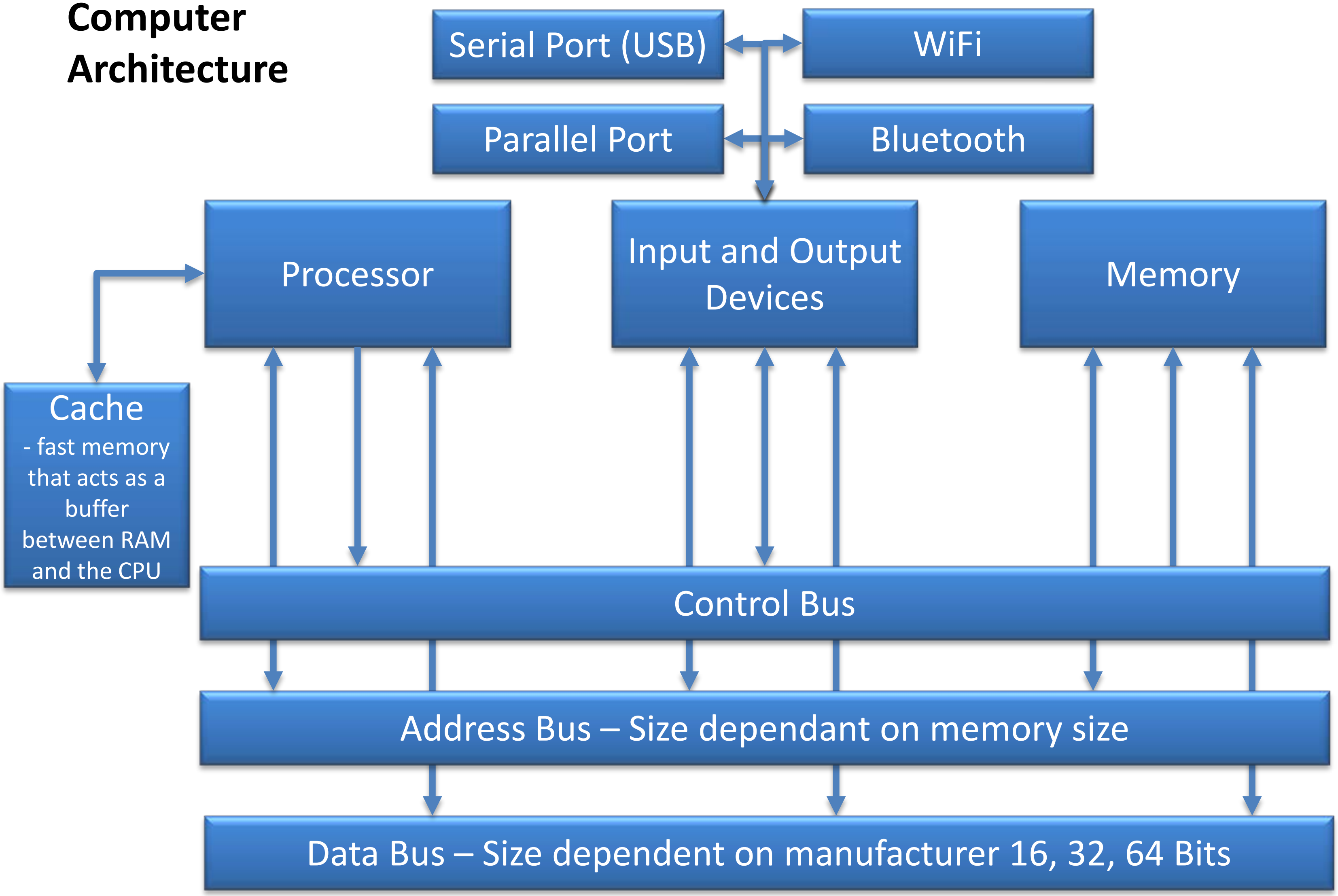
Computer Architecture



Computer Architecture

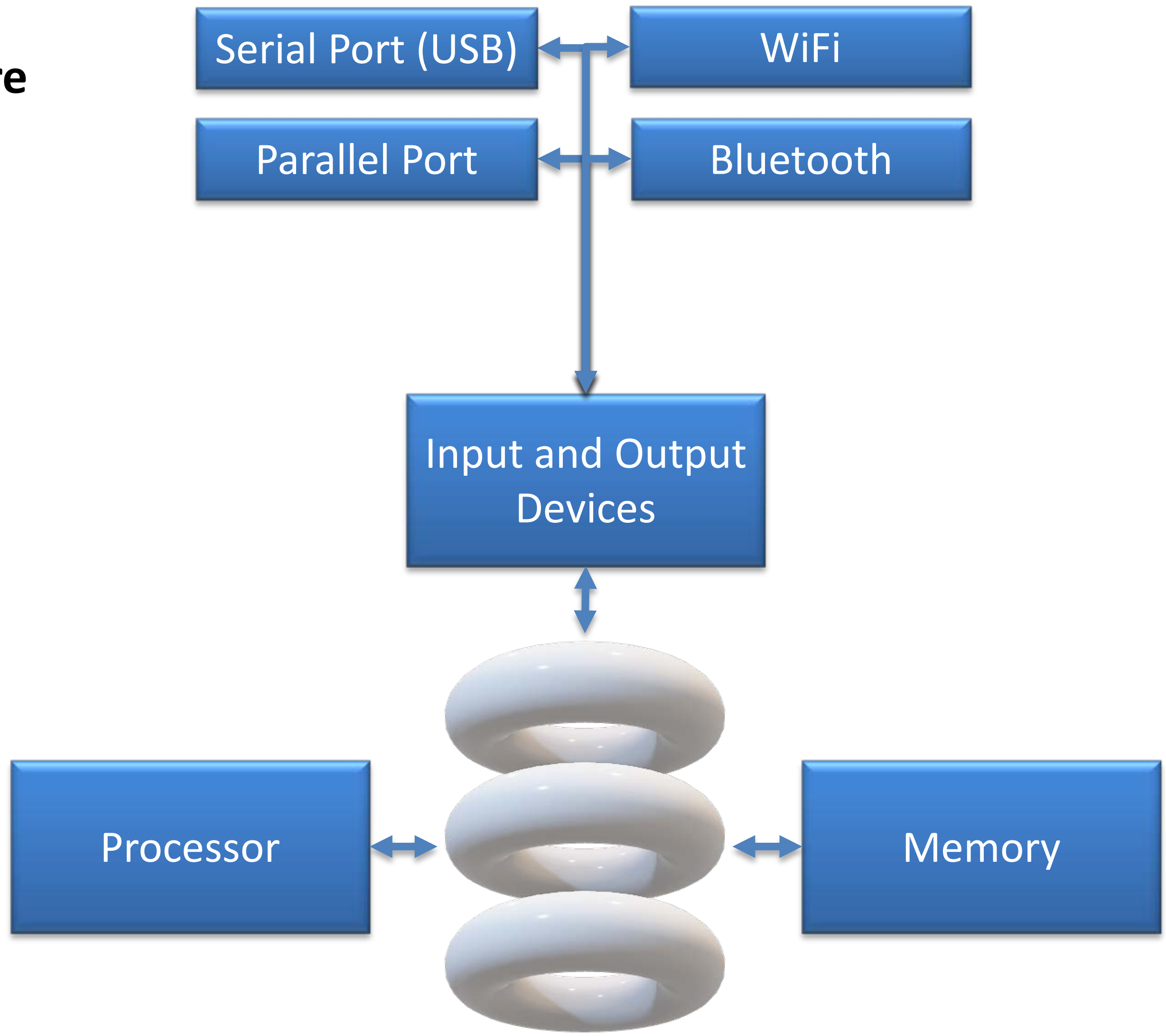


Computer Architecture



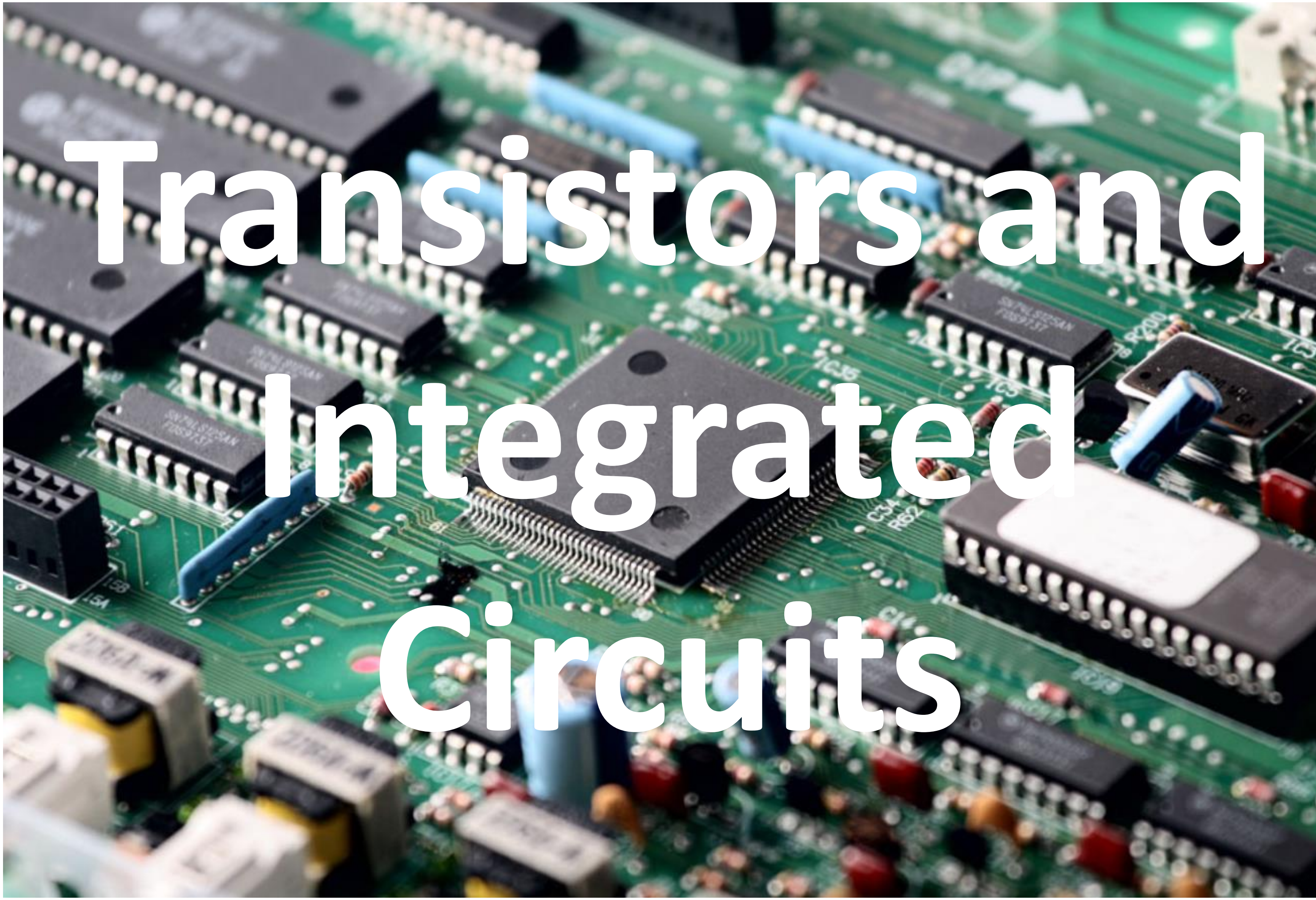

Main Frame
Computer 1970’s
IBM
ELECTRONIC DATA PROCESSING

Computer Architecture



Cray Supercomputer

Transistors and Integrated Circuits



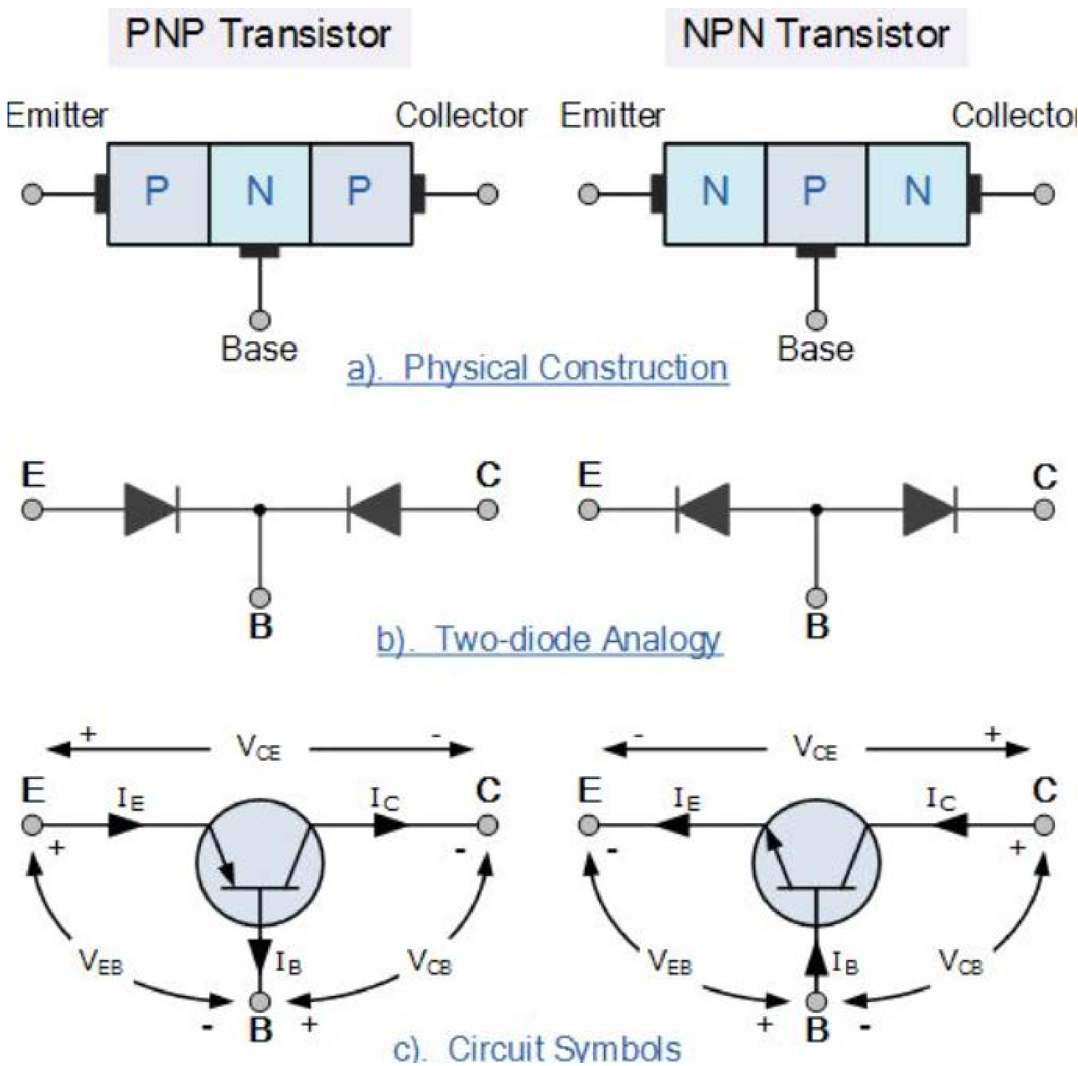
Transistors

1925 - The concept of a field-effect transistor was proposed by Julius Edgar Lilienfeld.

1947 - John Bardeen and Walter Brattain, while working under William Shockley at Bell Labs, built the first working transistor, the point-contact transistor.

1948 - Shockley's bipolar junction transistor.

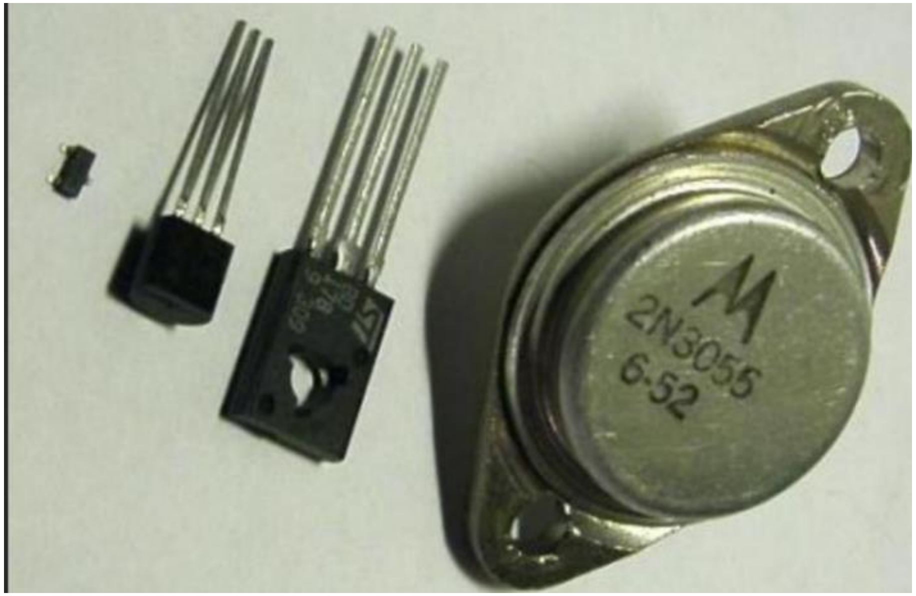
1955 - Transistors replaced vacuum tubes in computer designs, giving rise to the "second generation" of computers. Compared to vacuum tubes, transistors have many advantages: they are smaller, and require less power than vacuum tubes, so give off less heat. Junction transistors were much more reliable than vacuum tubes and had longer, indefinite, service life.

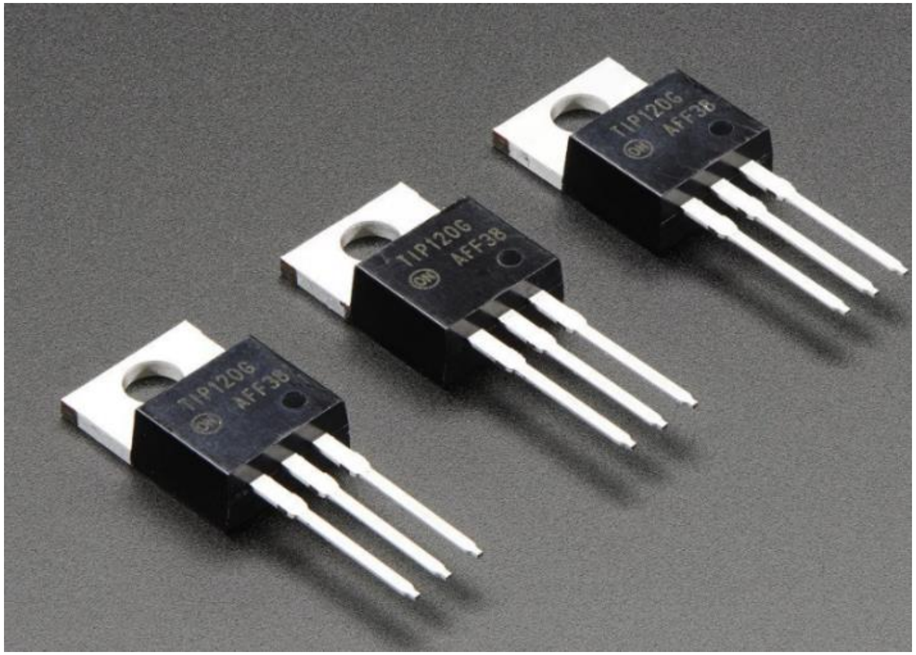


Transistors

1953 - At the University of Manchester, a team under the leadership of Tom Kilburn designed and built a machine using the newly developed transistors instead of valves. Their first transistorised computer and the first in the world, was operational.

1959 - The metal–oxide–silicon field-effect transistor (MOSFET), also known as the MOS transistor, was invented by Mohamed M. Atalla and Dawon Kahng at Bell Labs (silicon and germanium is used for the manufacture of transistors) . It was the first truly compact transistor that could be miniaturised and mass-produced for a wide range of uses. With its high scalability, and much lower power consumption and higher density than bipolar junction transistors, the MOSFET made it possible to build high-density integrated circuits. In addition to data processing, it also enabled the practical use of MOS transistors as memory cell storage elements, leading to the development of MOS semiconductor memory, which replaced earlier magnetic-core memory in computers. The MOSFET led to the microcomputer revolution, and became the driving force behind the computer revolution. The MOSFET is the most widely used transistor in computers, and is the fundamental building block of digital electronics.





Integrated circuits

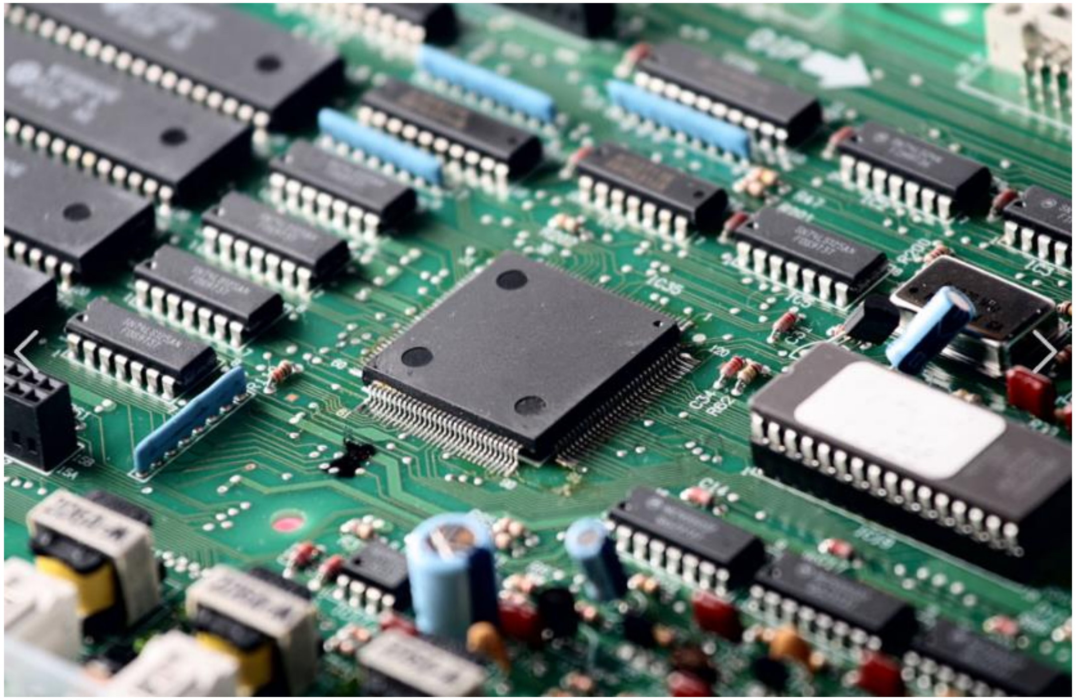
1952 - The next great advance in computing power came with the advent of the integrated circuit (IC). The idea of the integrated circuit was first conceived by a radar scientist working for the Royal Radar Establishment of the Ministry of Defence, Geoffrey W.A. Dummer.

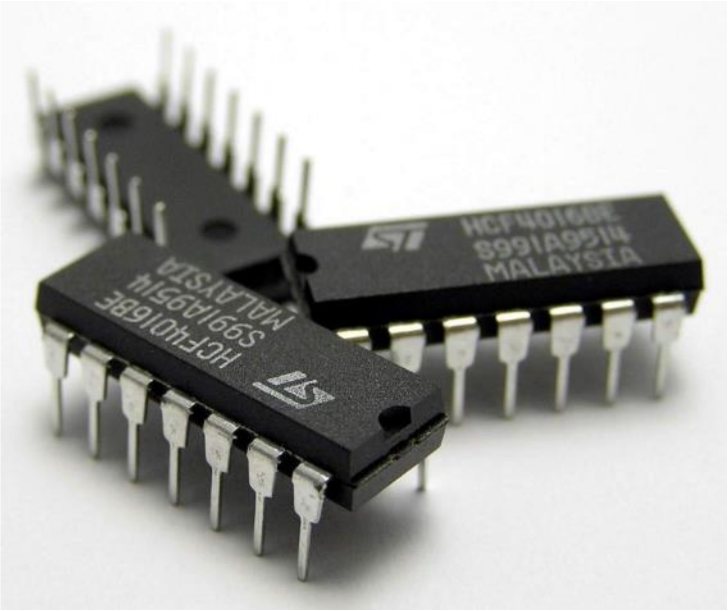
1958 - The first working ICs were invented by Jack Kilby at Texas Instruments and Robert Noyce at Fairchild Semiconductor. In his patent application of 6 February 1959, Kilby described his new device as "a body of semiconductor material ... wherein all the components of the electronic circuit are completely integrated". However, Kilby's invention was a hybrid integrated circuit (hybrid IC), rather than a monolithic integrated circuit (IC) chip. Noyce also came up with his own idea of an integrated circuit half a year later than Kilby. Noyce's invention was the first true monolithic IC chip. His chip solved many practical problems that Kilby's had not. Produced at Fairchild Semiconductor, it was made of silicon, whereas Kilby's chip was made of germanium.

1962 - Modern monolithic ICs are predominantly MOS (metal-oxide-semiconductor) integrated circuits, built from MOSFETs (MOS transistors). The earliest experimental MOS IC to be fabricated was a 16-transistor chip built by Fred Heiman and Steven Hofstein at RCA.

The development of the MOS integrated circuit led to the invention of the microprocessor, and heralded an explosion in the commercial and personal use of computers.

1970’s - MOS IC technology enabled the integration of more than 10,000 transistors on a single chip. System on a Chip (SoCs) are complete computers on a microchip (or chip) the size of a coin.

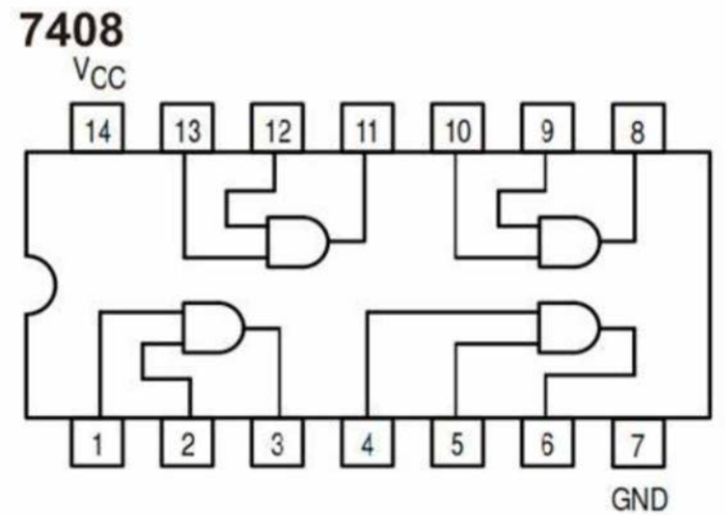


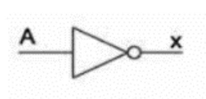
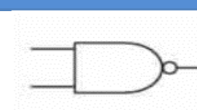
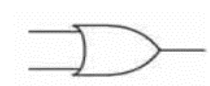


Adding Binary Numbers

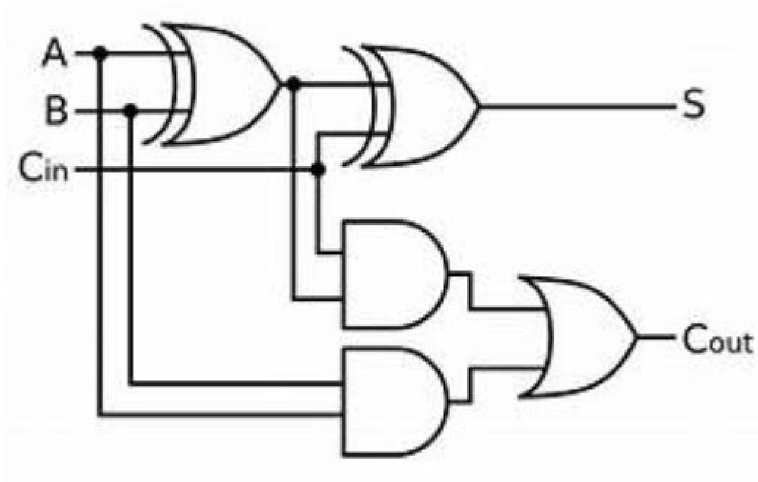
Examples of Decimal Addition	Result	Examples of Binary Addition	Result
0+0	0	0+0	0
0+1	1	0+1	1
3+4	7	1+0	1
6+7	3 carry 1	1+1	0 carry 1

Electronic Gates

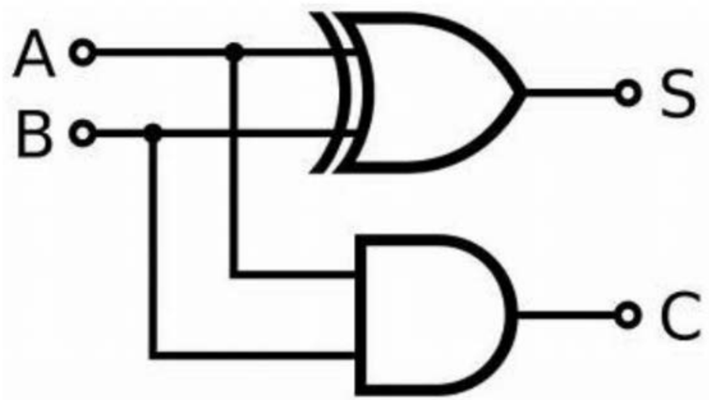


Gate	NOT		AND			NAND			OR			NOR		
Symbol														
Truth Table	A	X	A	B	X	A	B	X	A	B	X	A	B	X
			0	0	0	0	0	1	0	0	0	0	0	1
	0	1	0	1	0	0	1	1	0	1	1	0	1	0
	1	0	1	0	0	1	0	1	1	0	1	1	0	0
			1	1	1	1	1	0	1	1	1	1	1	0

2 Bit Half and Full Adder



Full Adder Circuit Diagram

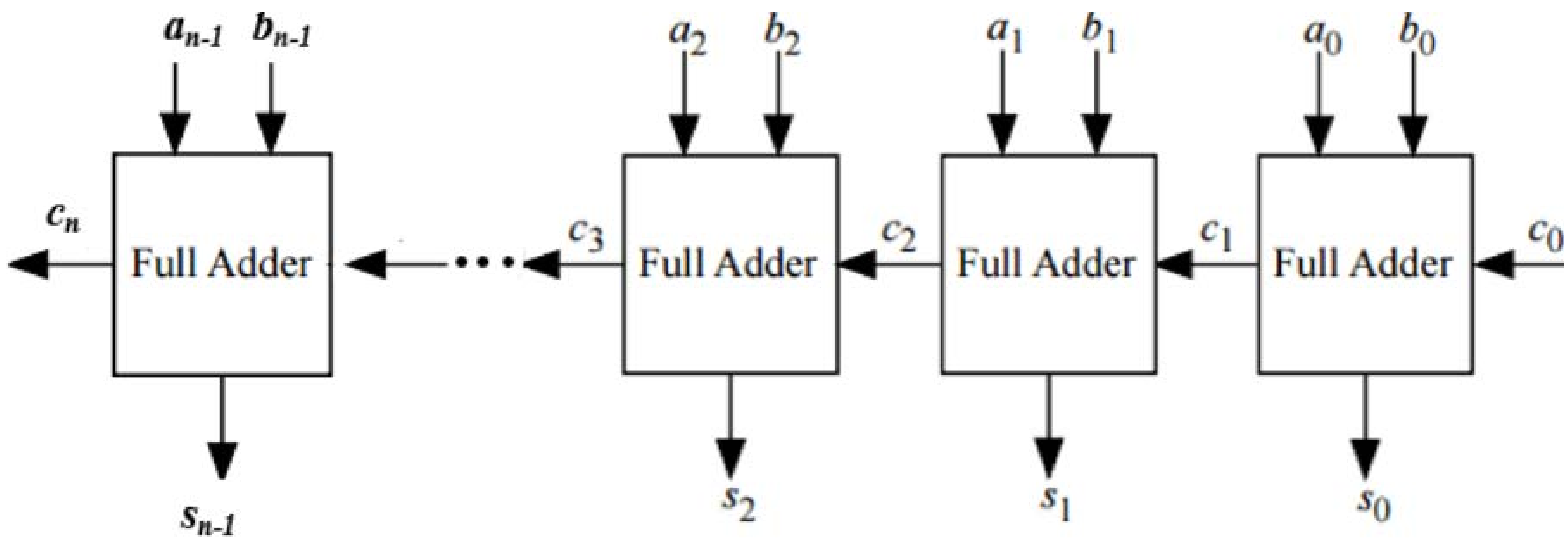


Half Adder Circuit

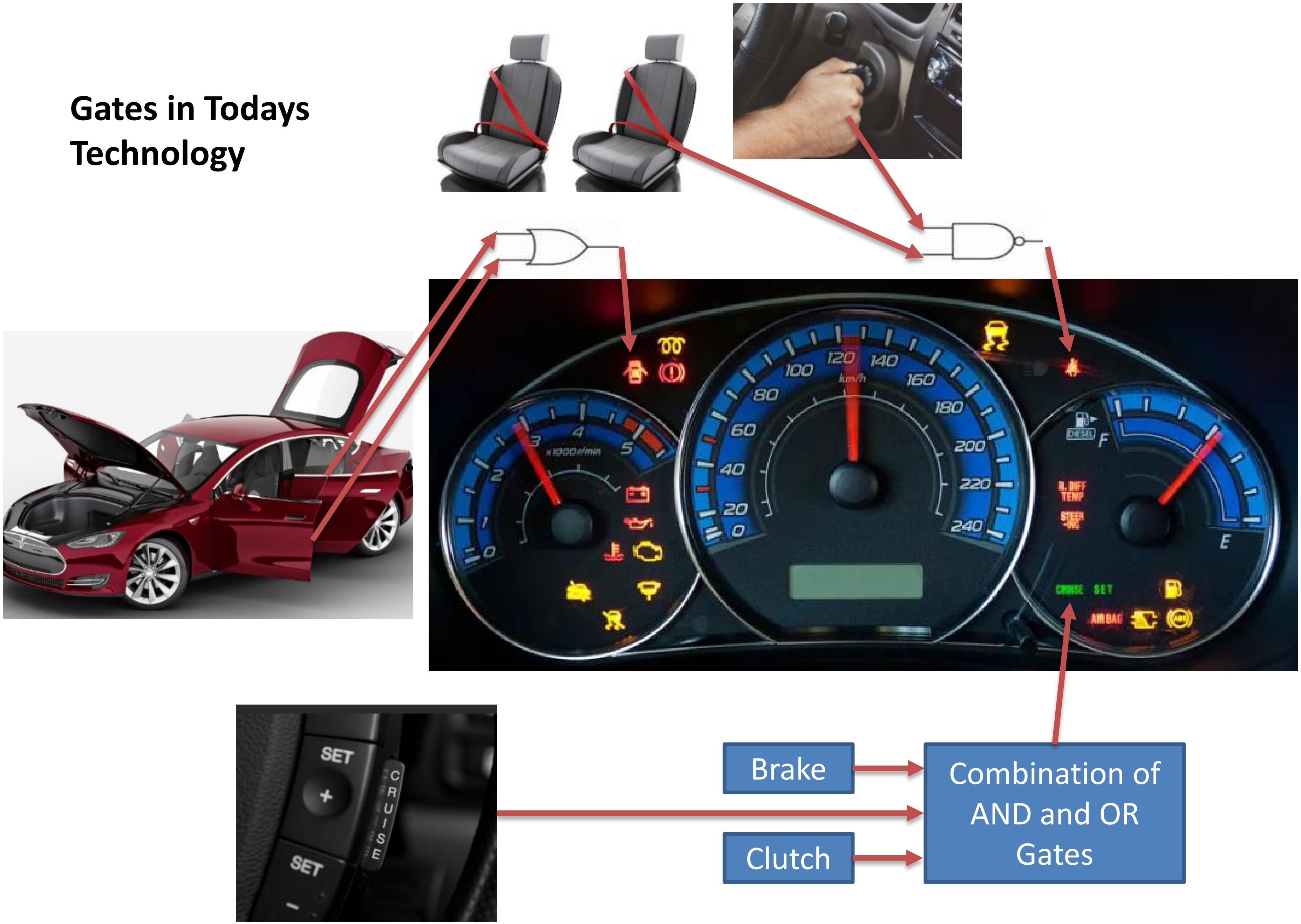
INPUTS		OUTPUTS	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

A	B	Cin	Sum	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

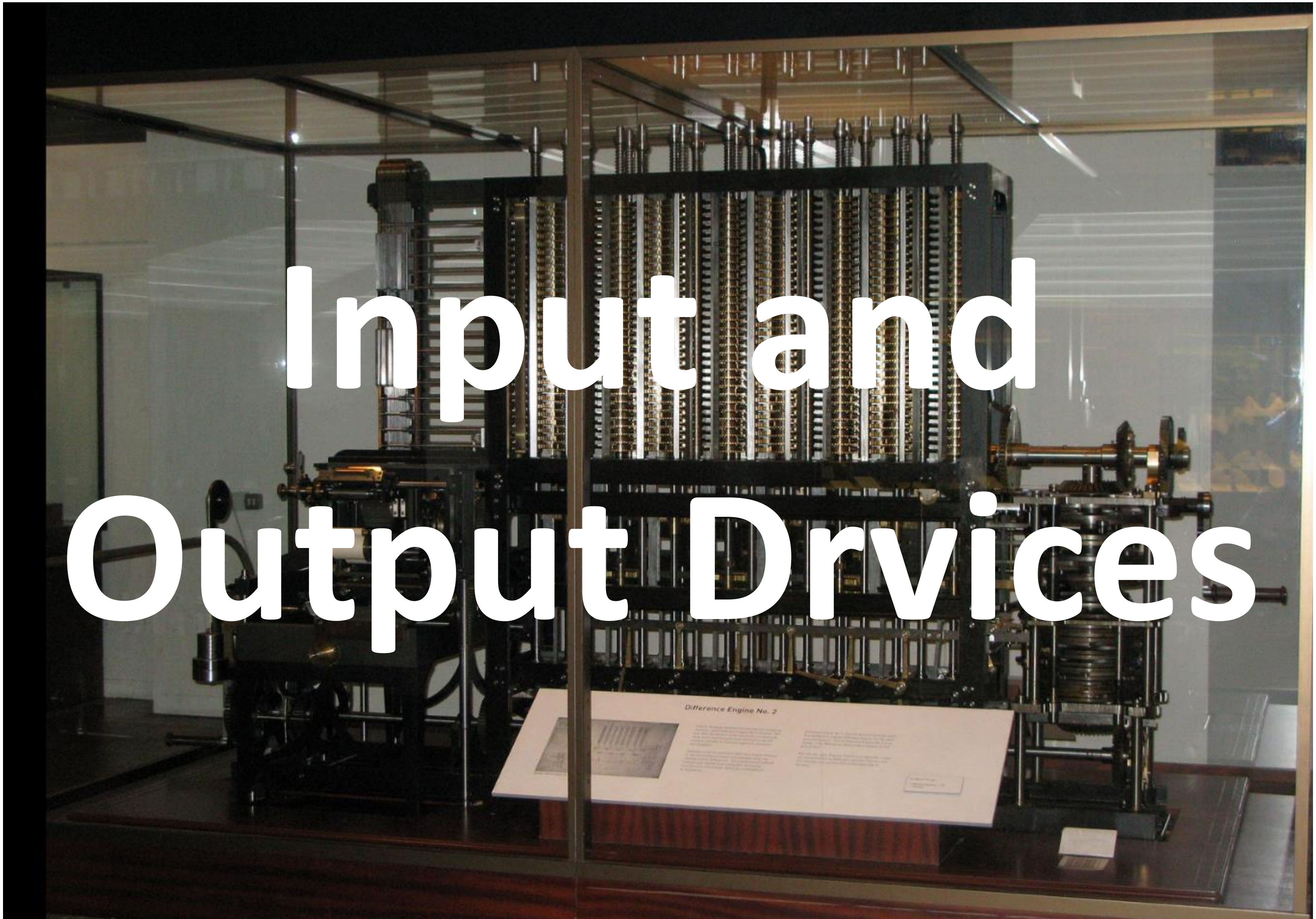
n-bit Full Adder



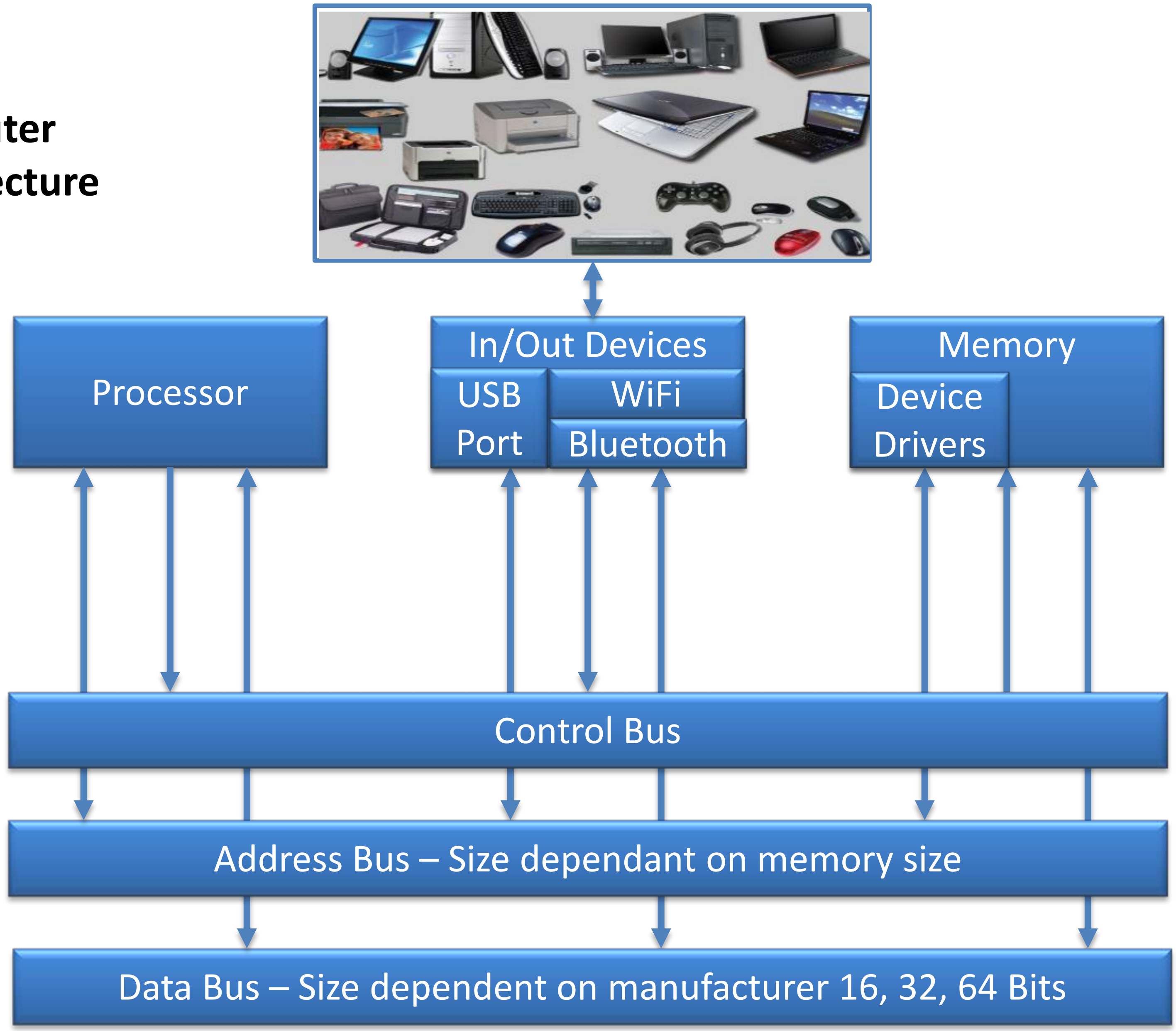
Gates in Todays Technology



Input and Output Drvices



Computer Architecture



Historic Input and Output Devices

Historic Magnetic Devices

Modern Input and Output Devices

The End