BINARY CODES AND BINARY STORAGE

DIGITAL LOGIC DESIGN

Iqra Chaudhary (Lecturer CS dept. NUML)

Binary codes

Digital system use signals that have two distinct values.

- Data is encoded with 0's and 1's

- Need codes for
  - Decimal number
  - Text characters
  - Floating point numbers
  - Images
  - Programs…
- "An n-bit binary code is a group of n bits that assume up to 2^n distinct combinations of 1's and 0's, with each combination representing one element of the set that is being coded."

Non-numeric Binary Codes

- Given n binary digits (called bits), a binary code is a mapping from a set of *represented elements* to a subset of the 2^n binary numbers.
- Example: A binary code for the seven colors of the rainbow
- Code 100 is not used

Color	Binary Number
Red	000
Orange	001
Yellow	010
Green	011
Blue	101
Indigo	110
Violet	111

Questions

- How many bits are required to represent in a binary code?
  - decimal digits
  - Hexadecimal digits
  - No. of dresses you own
  - Books you have read
  - Books in a library
  - No. of organs in your body

BINARY CODES FOR DECIMAL DIGITS

There are over 8,000 ways that you can chose 10 elements from the 16 binary numbers of 4 bits.

Binary Codes for Decimal Digits

- BCD code
- Excess-3 code
- 8421
- Gray code

Decimal	8,4,2,1	Excess3	8,4, -2, -1	Gray
0	0000	0011	0000	0000
1	0001	0100	0111	0100
2	0010	0101	0110	0101
3	0011	0110	0101	0111
4	0100	0111	0100	0110
5	0101	1000	1011	0010
6	0110	1001	1010	0011
7	0111	1010	1001	0001
8	1000	1011	1000	1001
9	1001	1100	1111	1000

Binary Codes: BCD Code/binary coded decimal

- BCD Code/binary coded decimal
  - *Binary Code to represent decimal digits 0-9*
  - *A decimal number in BCD is the same as its equivalent binary number only when the number is between 0 and 9.*
  - *The binary combinations 1010 through 1111 are not used and have no meaning in BCD.*

Table 1.4
Binary-Coded Decimal (BCD)

Decimal Symbol	BCD Digit
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Binary Codes: BCD Code/binary coded decimal

- A number with k decimal digits will require 4k bits in BCD.
- Decimal 396 is represented in BCD with 12bits as 0011 1001 0110, with each group of 4 bits representing one decimal digit.

Warning: Conversion or Coding?

- Do NOT mix up **conversion of a decimal number to a binary number** with **coding a decimal number with a BINARY CODE**.

Example:

$13_{10} = 1101_2$ (This is conversion)

13 0001 0011 (This is coding)

Consider decimal 185 and its corresponding value in BCD and binary:

$$(185)_{10} = (0001\ 1000\ 0101)_{BCD} = (10111001)_2$$

Binary Codes: BCD Code/binary coded decimal

Example (BCD):

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
11	0001 0001
12	0001 0010
13	0001 0011
14	0001 0100
15	0001 0101

Binary Codes:Excess-3 code

- Non weighted code
- Excess-3 code was used on some older computers and hand-held portable electronic calculators of the 1970s, among other uses.
- Excess-3 code start from 3(0011)

Table 1

Digit	Excess code
0	0011
1	0100
2	0101
3	0110
4	0111
5	1000
6	1001
7	1010
8	1011
9	1100

Binary Codes:Excess-3 code

EXAMPLE (Note: 2 digits represented by 2 4 bit numbers)

12 to excess-3 = 1+3=4 2+3=5

4 5

0100 0101

29 to excess-3 = 2+3=5 9+3=12

5 12

0101 1100

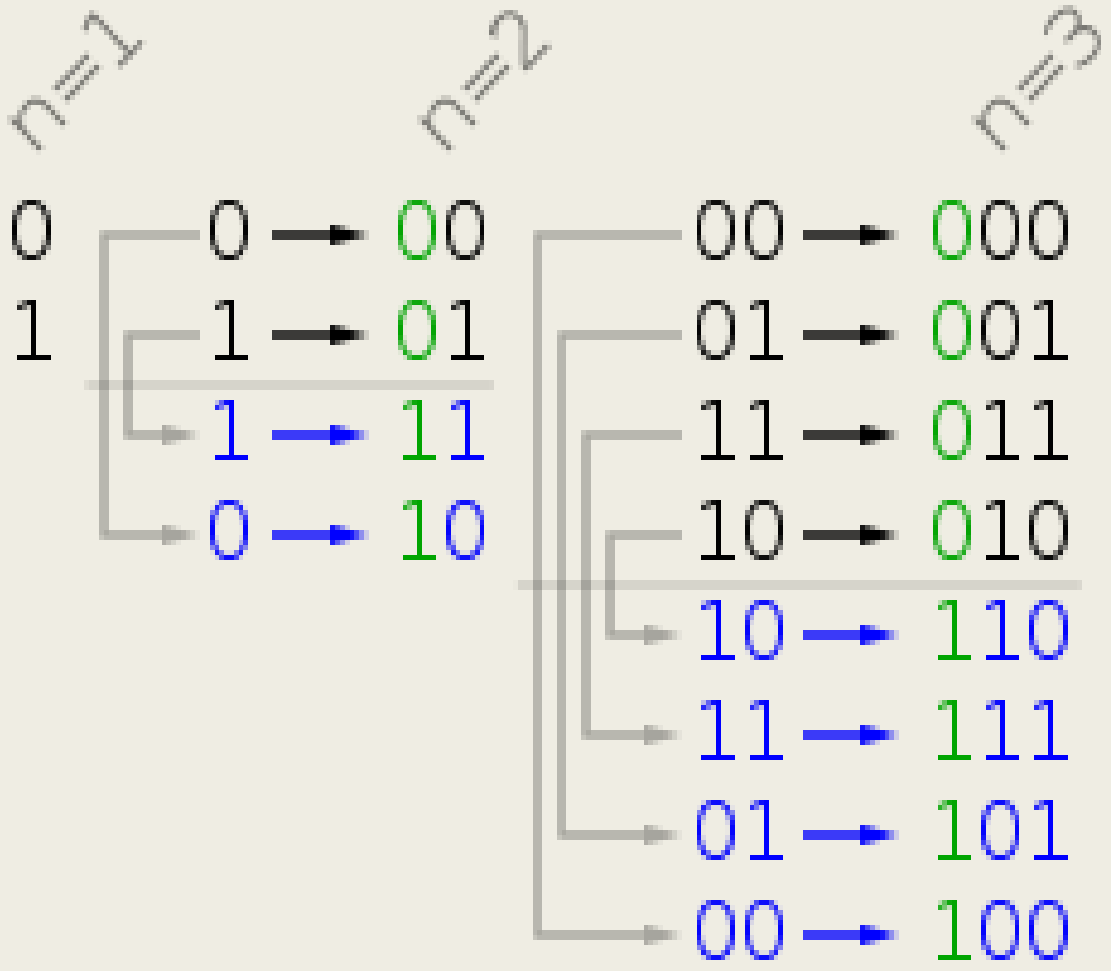
Binary Codes: Gray Code

- *The advantage is that only bit in the code group changes in going from one number to the next.*
  - Representation of analog data.
  - Error detection.

Table 1.6
Gray Code

Gray Code	Decimal Equivalent
0000	0
0001	1
0011	2
0010	3
0110	4
0111	5
0101	6
0100	7
1100	8
1101	9
1111	10
1110	11
1010	12
1011	13
1001	14
1000	15

Binary Codes: Gray Code



Binary Codes: Gray Code and binary code for 0-7 decimal

Decimal	Gray	Binary
0	000	000
1	001	001
2	011	010
3	010	011
4	110	100
5	111	101
6	101	110
7	100	111

ASCII Character Codes

- American Standard Code for Information Interchange A popular code used to represent information sent as character-based data.
- Numbers, Characters, Symbols
- It uses 7-bits to represent:
  - *94 Graphic printing characters.*
  - *34 Non-printing characters.*
- Some non-printing characters are used for text format (e.g. BS = Backspace, CR = carriage return).
- Other non-printing characters are used for flow control (e.g. STX and ETX start and end text areas).

Alphanumeric Code

- 10 Numbers (0-9)
- 26 Lower Case Characters (a-z)
- 26 Upper Case Characters (A-Z)
- 32 Control Characters
- Punctuation and Symbols

Alphanumeric Code

- American Standard Code for Information Interchange (ASCII) Character Code

Table 1.7
American Standard Code for Information Interchange (ASCII)

	$b_7b_6b_5$							
$b_4b_3b_2b_1$	000	001	010	011	100	101	110	111
0000	NUL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	−	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	−	o	DEL

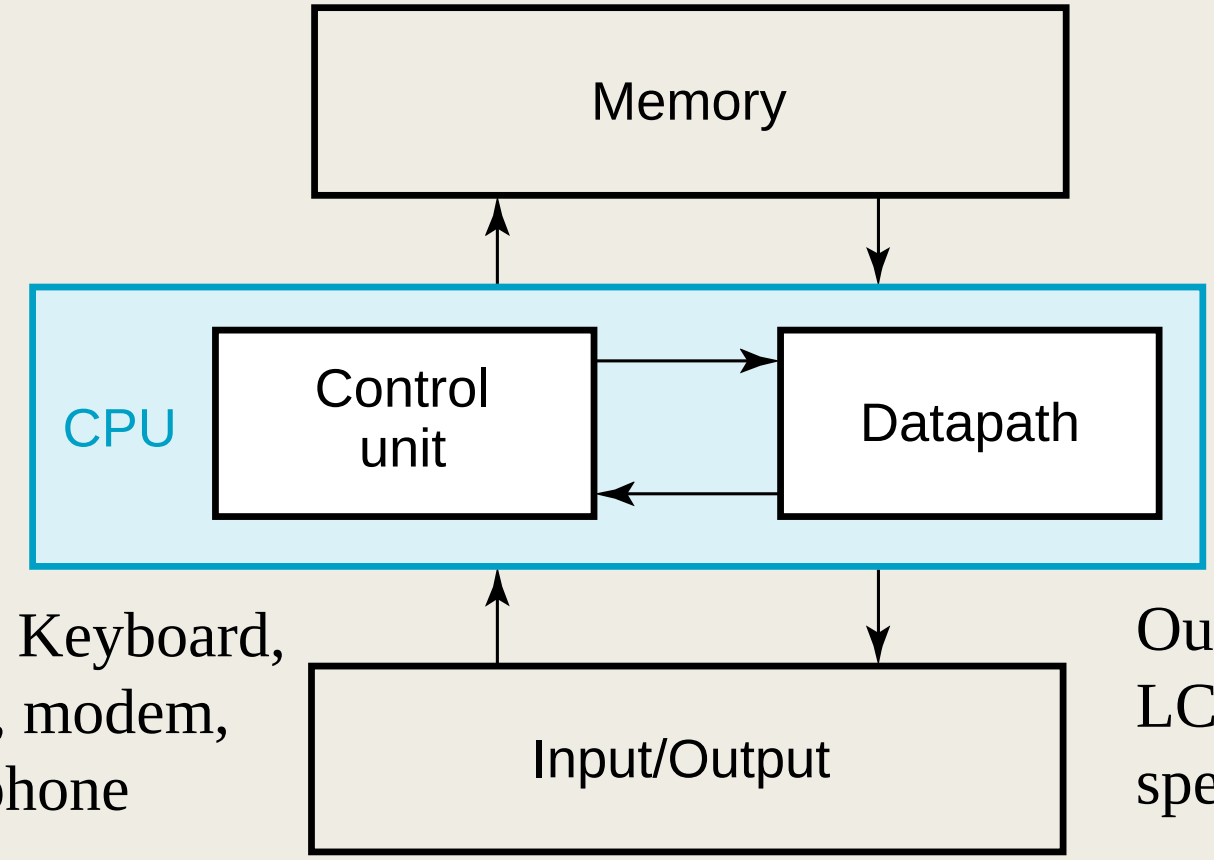
Binary Storage and Registers

- Registers
  - *A binary cell is a device that possesses two stable states and is capable of storing one of the two states.*
  - *A register is a group of binary cells. A register with n cells can store any discrete quantity of information that contains n bits.*

n cells → 2^n possible states

- A binary cell
  - *Two stable state*
  - *Store one bit of information*
  - *Examples: flip-flop circuits, ferrite cores, capacitor*
- A register
  - *A group of binary cells*
  - *AX in x86 CPU*
- Register Transfer
  - *A transfer of the information stored in one register to another.*
  - *One of the major operations in digital system.*
  - *An example in next slides.*

A Digital Computer Example



Inputs: Keyboard, mouse, modem, microphone

Outputs: CRT, LCD, modem, speakers

Synchronous or Asynchronous?

Transfer of information

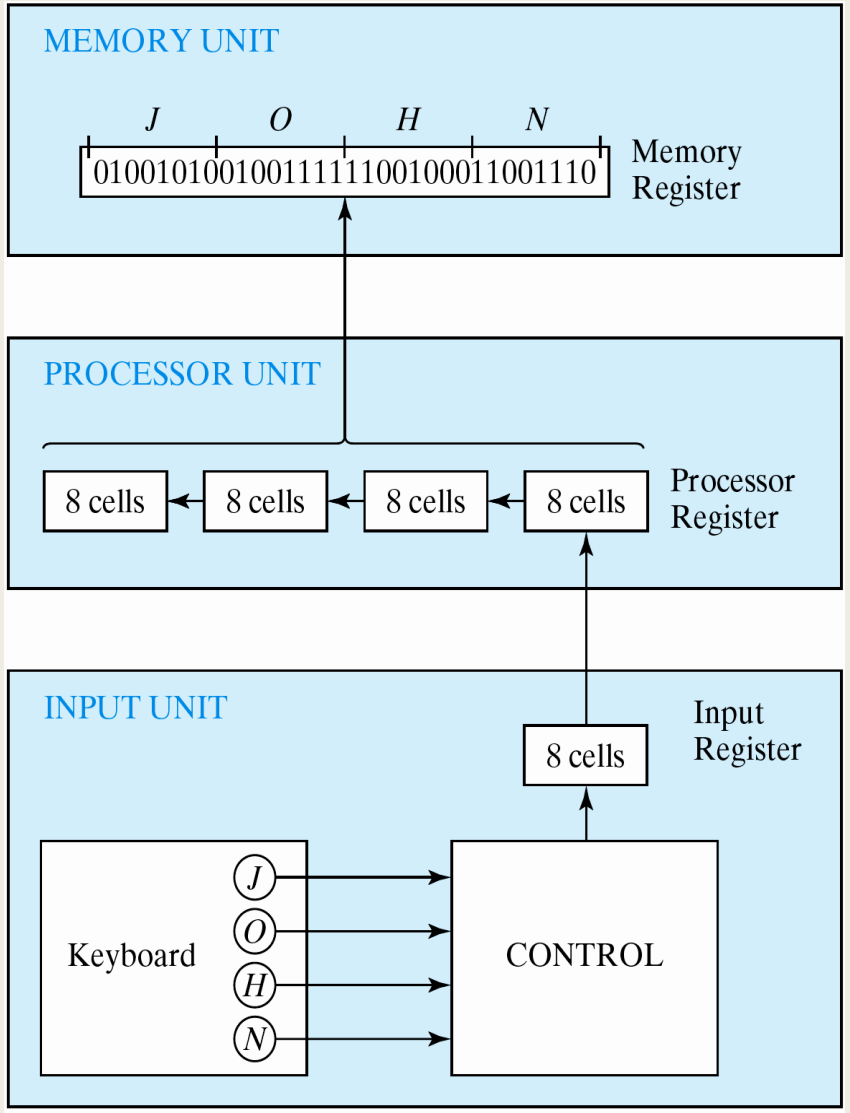


Figure 1.1 Transfer of information among register

Transfer of information

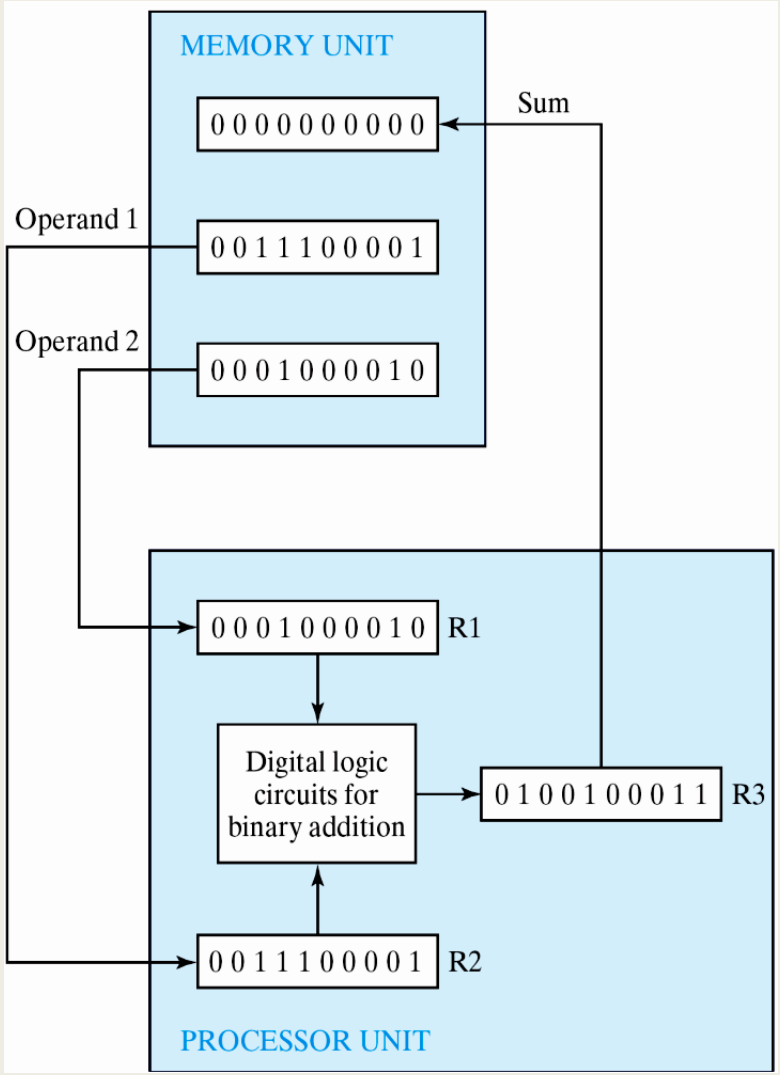


Figure 1.2 Example of binary information processing

- The other major component of a digital system
  - *Circuit elements to manipulate individual bits of information*
  - *Load-store machine*

```
LD    R1;
LD    R2;
ADD   R3, R2, R1;
SD    R3;
```

Thank You