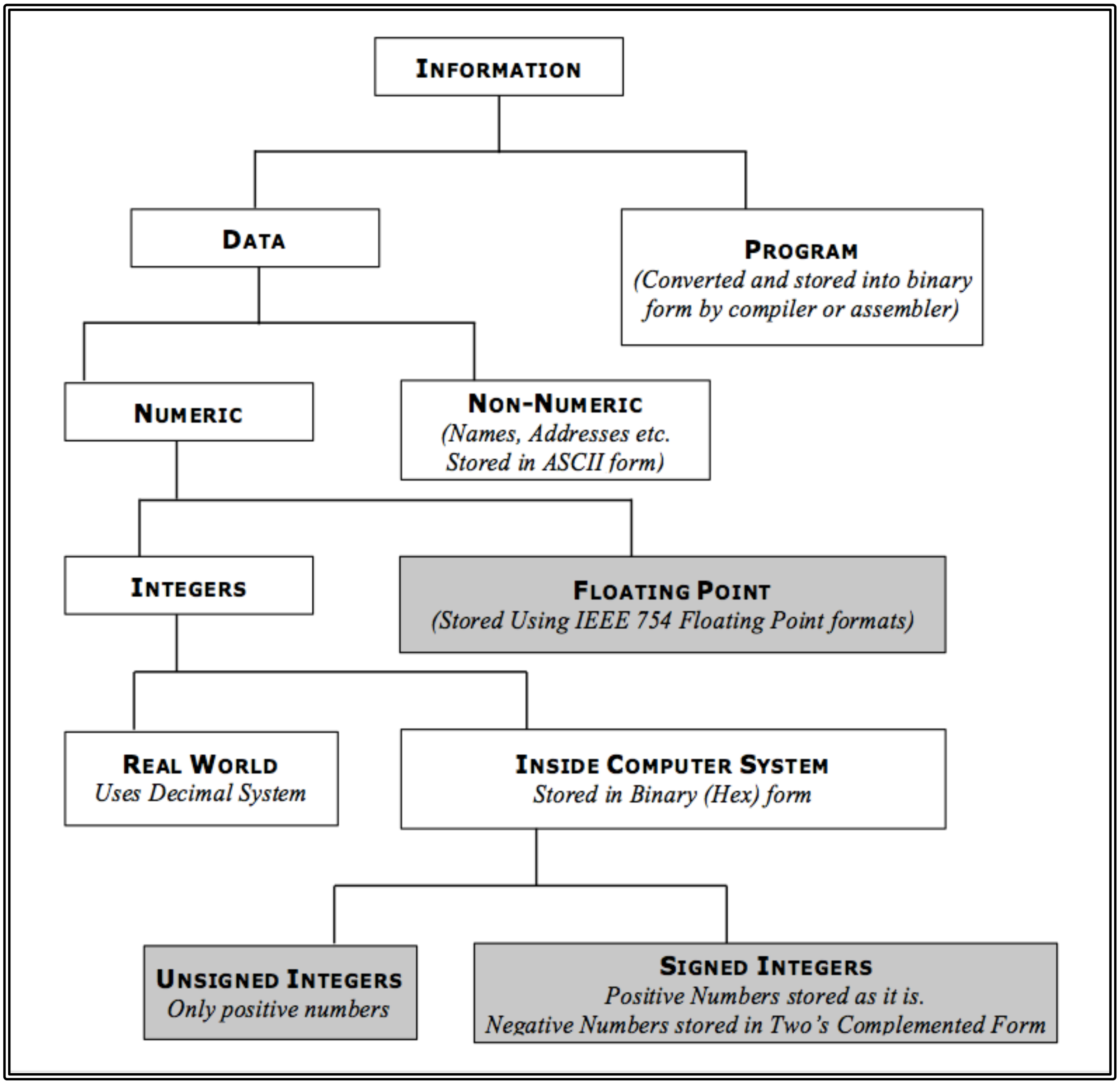
DATA REPRESENTATION & ARITHMETIC ALGORITHMS

INFORMATION

Information stored in the memory can be of the following categories.



UNSIGNED INTEGERS

These are binary numbers that are always assumed to be positive.
Here all available bits of the number are used to represent the magnitude of the number.
No bits are used to indicate its sign, hence they are called unsigned numbers.
E.g.: Roll Numbers, Memory addresses etc.

SIGNED INTEGERS

These are binary numbers that can be either positive or negative.
The MSB of the number indicates whether it is positive or negative.
If MSB is 0 then the number is Positive.
If MSB is 1 then the number is Negative.
Negative numbers are always stored in their 2's Complement form.

NUMBER	SIGN MAGNITUDE	ONE'S COMPLEMENT	TWO'S COMPLEMENT
3	011	011	011
2	010	010	010
1	001	001	001
0	000	000	000
-0	100	111	000
-1	101	110	011
-2	110	101	110
-3	111	100	101
-4	---	---	100

Negative numbers are stored in 2's Complement form due to two reasons as highlighted above.

1) **Two's complement gives a unique representation for zero.**
   Any other system gives a separate representation for +0 and for -0.
   This is absurd.
   In two's complement system, -(x) is stored as two's complement of (x).
   Applying the same rule for 0, -(0) should be stored as two's complement of 0.
   0 is stored as 000.
   So –(0) should be stored as two's complement of 000, which again is 000.
   Hence two's complement gives a unique representation for 0.

2) **It produces an additional number on the negative side.**
   As two's complement system produces a unique combination for 0, it has a spare combination '100' in the above case, and can be used to represent –(4).

INTEGER NUMBER REPRESENTATION

3 BIT INTEGER	
$2^3 = 8$ therefore 8 combinations	
Unsigned	Signed
0 … 7	-4 … -1 0 1 … 3

4 BIT INTEGER	
$2^4 = 16$ therefore 16 combinations	
Unsigned	Signed
0 … 15	-8 … -1 0 1 … 7

5 BIT INTEGER	
$2^5 = 32$ therefore 32 combinations	
Unsigned	Signed
0 … 31	-16 … -1 0 1 … 15

8 BIT INTEGER	
$2^8 = 256$ therefore 256 combinations	
Unsigned	Signed
0 … 255	-128 … -1 0 1 … 127

16 BIT INTEGER	
$2^{16} = 65536$ therefore 65536 combinations	
Unsigned	Signed
0 … 65535	-32768 … -1 0 1 … 32767

SIGNED NUMBER EXAMPLES		
+5	0101	
-5	1011	← *2's complement*
+9	01001	
-9	10111	← *2's complement*
+23	010111	
-23	101001	← *2's complement*