Binary Number System

How are integers stored ?

The most commonly used integer type is int which is a signed 32-bit type.

When you store an integer, its corresponding binary value is stored.

The way integers are stored differs for negative and positive numbers. For positive numbers the integral value is simply converted into binary value and for negative numbers their 2’s complement form is stored.

Let’s discuss How are Negative Numbers Stored?

Computers use 2's complement in representing signed integers because:

1. There is only one representation for the number zero in 2's complement, instead of two representations in sign-magnitude and 1's complement.

2. Positive and negative integers can be treated together in addition and subtraction. Subtraction can be carried out using the "addition logic".

Example:

int i = -4;
Steps to calculate Two’s Complement of -4 are as follows:

Step 1: Take Binary Equivalent of the positive value (4 in this case)
0000 0000 0000 0000 0000 0000 0000 0100

Step 2: Write 1's complement of the binary representation by inverting the bits
1111 1111 1111 1111 1111 1111 1111 1011

Step 3: Find 2's complement by adding 1 to the corresponding 1's complement

```
  1111 1111 1111 1111 1111 1111 1111 1011
+0000 0000 0000 0000 0000 0000 0000 0001
-----------------------------------------------------------
  1111 1111 1111 1111 1111 1111 1111 1100
```

Thus, integer -4 is represented by the binary sequence (1111 1111 1111 1111 1111 1111 1111 1100) in Java.

Range of number which we can store with n bits :

$- 2^{n-1}\ to\ 2^{n-1} - 1$

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byte	1 byte	8 bits	$- 2^{8-1}\ to\ 2^{8-1} - 1$	$- 128\ to\ 127$
short	2 byte	16 bits	$- 2^{16-1}\ to\ 2^{16-1} - 1$	$- 32768\ to\ 32767$
int	4 byte	32 bits	$- 2^{32-1}\ to\ 2^{32-1} - 1$	$- 2^{31}\ to\ 2^{31} - 1$
long	8 bytes	64 bits	$- 2^{64-1}\ to\ 2^{64-1} - 1$	$- 2^{63}\ to\ 2^{63} - 1$

c) How are characters stored

Java uses Unicode to represent characters. As we know the system only understands binary language and thus everything has to be stored in the form binaries. So for every character there is a corresponding code – Unicode/ASCII code and the binary equivalent of this code is actually stored in memory when we try to store a char.

Unicode defines a fully international character set that can represent all the characters found in all human languages. In Java, char is a 16-bit type. The range of a char is 0 to 65,536.

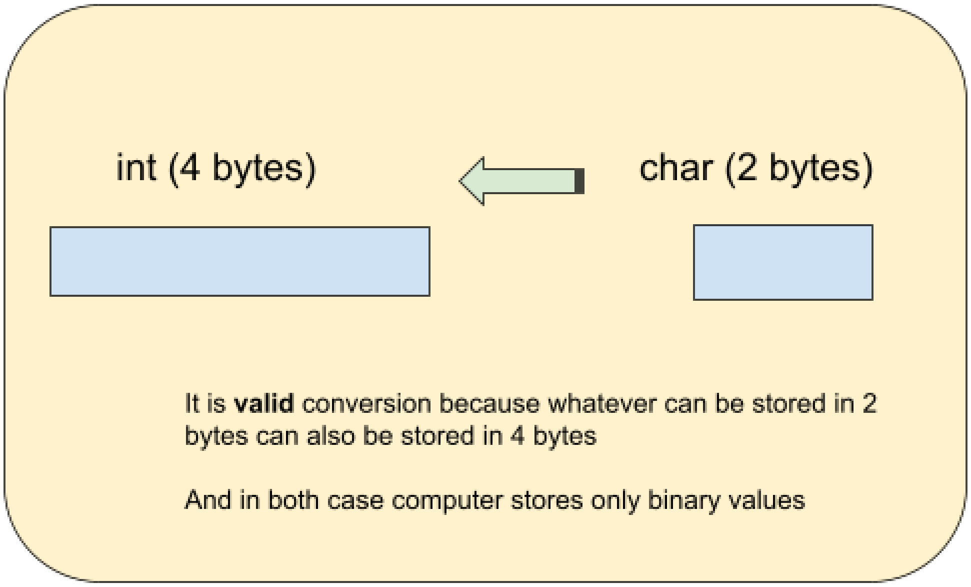
ASCII TABLE

Decimal	Hexadecimal	Binary	Octal	Char
0	0	0	0	*[NULL]*
1	1	1	1	*[START OF HEADING]*
2	2	10	2	*[START OF TEXT]*
3	3	11	3	*[END OF TEXT]*
4	4	100	4	*[END OF TRANSMISSION]*
5	5	101	5	*[ENQUIRY]*
6	6	110	6	*[ACKNOWLEDGE]*
7	7	111	7	*[BELL]*
8	8	1000	10	*[BACKSPACE]*
9	9	1001	11	*[HORIZONTAL TAB]*
10	A	1010	12	*[LINE FEED]*
11	B	1011	13	*[VERTICAL TAB]*
12	C	1100	14	*[FORM FEED]*
13	D	1101	15	*[CARRIAGE RETURN]*
14	E	1110	16	*[SHIFT OUT]*
15	F	1111	17	*[SHIFT IN]*
16	10	10000	20	*[DATA LINK ESCAPE]*
17	11	10001	21	*[DEVICE CONTROL 1]*
18	12	10010	22	*[DEVICE CONTROL 2]*
19	13	10011	23	*[DEVICE CONTROL 3]*
20	14	10100	24	*[DEVICE CONTROL 4]*
21	15	10101	25	*[NEGATIVE ACKNOWLEDGE]*
22	16	10110	26	*[SYNCHRONOUS IDLE]*
23	17	10111	27	*[ENG OF TRANS. BLOCK]*
24	18	11000	30	*[CANCEL]*
25	19	11001	31	*[END OF MEDIUM]*
26	1A	11010	32	*[SUBSTITUTE]*
27	1B	11011	33	*[ESCAPE]*
28	1C	11100	34	*[FILE SEPARATOR]*
29	1D	11101	35	*[GROUP SEPARATOR]*
30	1E	11110	36	*[RECORD SEPARATOR]*
31	1F	11111	37	*[UNIT SEPARATOR]*
32	20	100000	40	*[SPACE]*
33	21	100001	41	!
34	22	100010	42	"
35	23	100011	43	#
36	24	100100	44	$
37	25	100101	45	%
38	26	100110	46	&
39	27	100111	47	'
40	28	101000	50	(
41	29	101001	51	)
42	2A	101010	52	*
43	2B	101011	53	+
44	2C	101100	54	,
45	2D	101101	55	-
46	2E	101110	56	.
47	2F	101111	57	/
48	30	110000	60	0
49	31	110001	61	1
50	32	110010	62	2
51	33	110011	63	3
52	34	110100	64	4
53	35	110101	65	5
54	36	110110	66	6
55	37	110111	67	7
56	38	111000	70	8
57	39	111001	71	9
58	3A	111010	72	:
59	3B	111011	73	;
60	3C	111100	74	<
61	3D	111101	75	=
62	3E	111110	76	>
63	3F	111111	77	?
64	40	1000000	100	@
65	41	1000001	101	A
66	42	1000010	102	B
67	43	1000011	103	C
68	44	1000100	104	D
69	45	1000101	105	E
70	46	1000110	106	F
71	47	1000111	107	G
72	48	1001000	110	H
73	49	1001001	111	I
74	4A	1001010	112	J
75	4B	1001011	113	K
76	4C	1001100	114	L
77	4D	1001101	115	M
78	4E	1001110	116	N
79	4F	1001111	117	O
80	50	1010000	120	P
81	51	1010001	121	Q
82	52	1010010	122	R
83	53	1010011	123	S
84	54	1010100	124	T
85	55	1010101	125	U
86	56	1010110	126	V
87	57	1010111	127	W
88	58	1011000	130	X
89	59	1011001	131	Y
90	5A	1011010	132	Z
91	5B	1011011	133	[
92	5C	1011100	134	\
93	5D	1011101	135	]
94	5E	1011110	136	^
95	5F	1011111	137	_
96	60	1100000	140	`
97	61	1100001	141	a
98	62	1100010	142	b
99	63	1100011	143	c
100	64	1100100	144	d
101	65	1100101	145	e
102	66	1100110	146	f
103	67	1100111	147	g
104	68	1101000	150	h
105	69	1101001	151	i
106	6A	1101010	152	j
107	6B	1101011	153	k
108	6C	1101100	154	l
109	6D	1101101	155	m
110	6E	1101110	156	n
111	6F	1101111	157	o
112	70	1110000	160	p
113	71	1110001	161	q
114	72	1110010	162	r
115	73	1110011	163	s
116	74	1110100	164	t
117	75	1110101	165	u
118	76	1110110	166	v
119	77	1110111	167	w
120	78	1111000	170	x
121	79	1111001	171	y
122	7A	1111010	172	z
123	7B	1111011	173	{
124	7C	1111100	174	|
125	7D	1111101	175	}
126	7E	1111110	176	~
127	7F	1111111	177	*[DEL]*

Typecasting

Type conversion: Converting one type of data to another

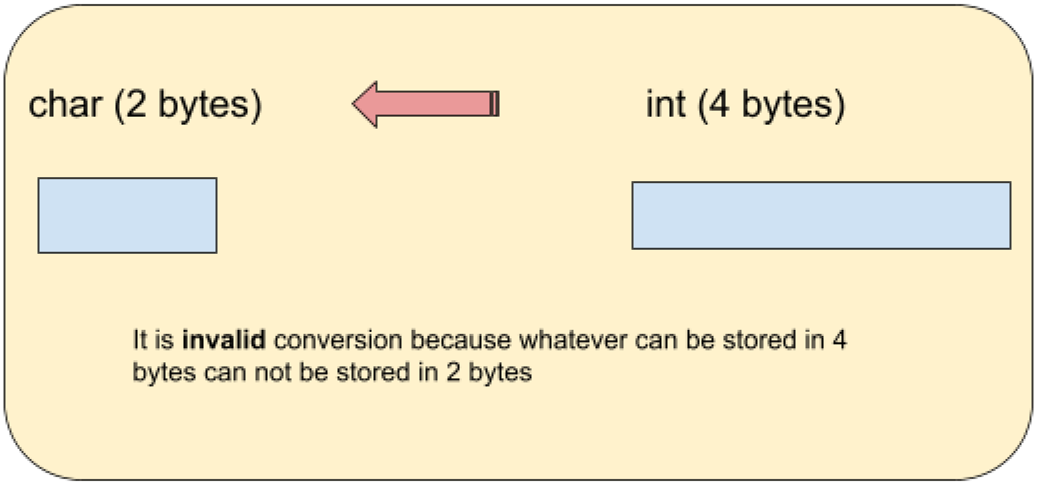
1. char to int



It is **valid** conversion because whatever can be stored in 2 bytes can also be stored in 4 bytes

And in both case computer stores only binary values

2. int to char



It is **invalid** conversion because whatever can be stored in 4 bytes can not be stored in 2 bytes

```
// implicit conversion


        //(char to int)
        char ch = 'a';
        int i = ch;
        System.out.println(i);

        //output: 97


        //(int to char)
        int i2 = 97;
        char ch2 = i2;
        System.out.println(ch2);

        //output: error!
```

```
//explicit conversion

        int i3 = 99;
        char ch3 = (char)i3;

        //there can be data loss as we are converting int to char as in
        // 4 bytes to 2 bytes

        System.out.println(ch3);

        //output: c
```

```
ch = ch + 1; //error

// because on RHS   2 bytes + 4 bytes so result is 4 bytes
// and LHS is of 2 bytes so by default it gives error

// But we can do explicit conversion

ch = (char)(ch+1);  // no error
```

```
       // int + int = int
       System.out.println(4+4);
       //output: 8

       // double + int = double
       System.out.println(4.1 + 4);
       //output: 8.1

       // double + double = double
       System.out.println(4.1 + 4.2);
       //output: 8.3
```

Note:

Automatic type casting happens in java when two types are compatible and destination type is larger

Relational Operators

==	Check if the two operands are equal
!=	Check if the two operands are not equal
>	Check if the left operand is greater than right operand
<	Check if the left operand is smaller than right operand
>=	Check if the left operand is greater than or equal to right operand
<=	Check if the left operand is less than or equal to right operand

Logical Operators

&&	Logical AND
||	Logical OR
!	Logical NOT