

Bits and Bytes

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Unix Epoch Time and Y2K38 Problem on 32 Bit architecture

0000 0000 0000 0000 0000 0000 0000 000000

- Unix Time defined as the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970. It is also called epoch time or POSIX time.
- Unix time is typically encoded as a signed integer.
- The Unix time 0 is exactly midnight UTC on 1 January 1970, with Unix time incrementing by 1 for every non-leap second after this.
- Even though majority of the modern computers are now 64 bit, there may be a significant amount of 32 bit computers and hardware still being used, and many programs are still using 32bit signed integer field.
- The maximum value of a signed 32 bit integer is $2^{31}-1$, and the minimum value is $-(2^{31})$. This means they have just enough storage to store numbers as large as 2147483647 and will experience an overflow problem on 19 January 2038.
- This makes it impossible to represent dates before 13 December 1901 (at 20:45:52 UTC) or after 19 January 2038 (at 03:14:07 UTC).
- The late cut off on January 19, 2038, at 3:14:07 is called Y2K38 problem as the Unix time would wrap back to year 1901 and will cause issues on all hardware with 32 bit architecture.
- The Date cut off on a 64 bit architecture is 292 billion years in either direction of 1970 epoch and is not an issue ($2^{63}-1$ and $-(2^{63})$).
- Unix time can be checked using the command 'date +%s'
- This problem is more significant than Y2K problem as you have to upgrade your hardware as well to solve this problem.

Bits, Bytes and Patterns

- A "bit" is the smallest unit of storage
- A bit stores just a 0 or 1
- In the computer it's all 0's and 1's" ... bits
- A bit is too small to be much use
- Group 8 bits together to make 1 byte
- One byte = collection of 8 bits
- e.g. 0 0 0 0 1 1 1 1
- One byte can store one character, e.g. 'A' or 'x' or '\$'
- Mathematically: n bits yields 2^n patterns (2 to the nth power)

Number of Bits	Patterns
1	0 1
2	00 01 10 11
3	000 001 010 100 011 101 110 111
4	0000 0001 0010 0100 1000 0011 0101 0110 1001 1010 1100 0111 1011 1101 1110 1111

Binary, Hexadecimal and Binary to Decimal Conversion



Decimal	Binary (Base 2)	Binary to Decimal Conversion (unsigned integer)	Hexadecimal (Base16)
0	0000 0000		0
1	0000 0001	$2^0 \times 1 = 1 \times 1 = 1$	1
2	0000 0010	$2^1 \times 1 + 2^0 \times 0 = 2 + 0 = 2$	2
3	0000 0011	$2^1 \times 1 + 2^0 \times 1 = 2 + 1 = 3$	3
4	0000 0100	$2^2 \times 1 + 2^1 \times 0 + 2^0 \times 0 = 4 + 0 + 0 = 4$	4
5	0000 0101	$2^2 \times 1 + 2^1 \times 0 + 2^0 \times 1 = 4 + 0 + 1 = 5$	5
6	0000 0110	$2^2 \times 1 + 2^1 \times 1 + 2^0 \times 0 = 4 + 2 + 0 = 6$	6
7	0000 0111	$2^2 \times 1 + 2^1 \times 1 + 2^0 \times 1 = 4 + 2 + 1 = 7$	7
8	0000 1000	$2^3 \times 1 + 2^2 \times 0 + 2^1 \times 0 + 2^0 \times 0 = 8 + 0 + 0 + 0 = 8$	8
9	0000 1001	$2^3 \times 1 + 2^2 \times 0 + 2^1 \times 0 + 2^0 \times 1 = 8 + 0 + 0 + 1 = 9$	9
10	0000 1010	$2^3 \times 1 + 2^2 \times 0 + 2^1 \times 1 + 2^0 \times 0 = 8 + 0 + 2 + 0 = 10$	A
11	0000 1011	$2^3 \times 1 + 2^2 \times 0 + 2^1 \times 1 + 2^0 \times 1 = 8 + 0 + 2 + 1 = 11$	B
12	0000 1100	$2^3 \times 1 + 2^2 \times 1 + 2^1 \times 0 + 2^0 \times 0 = 8 + 4 + 0 + 0 = 12$	C
13	0000 1101	$2^3 \times 1 + 2^2 \times 1 + 2^1 \times 0 + 2^0 \times 1 = 8 + 4 + 0 + 1 = 13$	D
14	0000 1110	$2^3 \times 1 + 2^2 \times 1 + 2^1 \times 1 + 2^0 \times 0 = 8 + 4 + 2 + 0 = 14$	E
15	0000 1111	$2^3 \times 1 + 2^2 \times 1 + 2^1 \times 1 + 2^0 \times 1 = 8 + 4 + 2 + 01 = 15$	F

4bit signed Integer in two's complement notation

Decimal	Binary	Decimal	Binary
-8	1000	0	0000
-7	1001	1	0001
-6	1010	2	0010
-5	1011	3	0011
-4	1100	4	0100
-3	1101	5	0101
-2	1110	6	0110
-1	1111	7	0111

Side by Side Comparison of outputs from 32 bit and 64 bit RaspberryPi Operating System

```
pi@raspberrypi:~/DevOps/Y2K38 $ getconf LONG_BIT
32
pi@raspberrypi:~/DevOps/Y2K38 $ ./a.out
This program tests time related issues regarding Year 2038 (Y2k38) !
Current seconds since January 1, 1970 = 1708447726

Test whether you are running a 32 bit or 64 bit OS
Your system is running 32 bit OS
sizeof(int): 4
sizeof(long long int): 8
sizeof(time_t): 4
Local time and date: Tue Feb 20 08:48:46 2024

UTC time and date: Tue Feb 20 16:48:46 2024

2147483647, Tue Jan 19 03:14:07 2038
-2147483648, Fri Dec 13 20:45:52 1901
-2147483647, Fri Dec 13 20:45:53 1901
-2147483646, Fri Dec 13 20:45:54 1901
pi@raspberrypi:~/DevOps/Y2K38 $ python3 ./test_year2k38.py
Current UTC time = 2024-02-20 16:48:53.937185
Current Local time = 2024-02-20 08:48:53.939419
Last time that can be stored on 32 bit os 2038-01-18 19:14:07
Traceback (most recent call last):
  File "./test_year2k38.py", line 10, in <module>
    print ("Next Second on 64 bit OS ", datetime.fromtimestamp(epoch_seconds+1))
OverflowError: timestamp out of range for platform time_t
pi@raspberrypi:~/DevOps/Y2K38 $ perl ./test_year2k38.pl
Tue Jan 19 03:14:06 2038
Tue Jan 19 03:14:07 2038
Tue Jan 19 03:14:07 2038
Tue Jan 19 03:14:07 2038
Tue Jan 19 03:14:07 2038
Last time in seconds that can be stored on a 32 bit machine 2147483647
Last day on 32/64 bit Tue Jan 19 03:14:07 2038
Current time on 32 bit/64 bit Tue Jan 19 03:14:07 2038

Next time after a second increment on 32 bit/64 bit Tue Jan 19 03:14:07 2038
```

```
ppk@raspberrypi:~/DevOps/Y2K38 $ getconf LONG_BIT
64
ppk@raspberrypi:~/DevOps/Y2K38 $ ./a.out
This program tests time related issues regarding Year 2038 (Y2k38) !
Current seconds since January 1, 1970 = 1708447646

Test whether you are running a 32 bit or 64 bit OS
Your system is running 64 bit OS
sizeof(int): 4
sizeof(long long int): 8
sizeof(time_t): 8
Local time and date: Tue Feb 20 08:47:26 2024

UTC time and date: Tue Feb 20 16:47:26 2024

2147483647, Tue Jan 19 03:14:07 2038
2147483648, Tue Jan 19 03:14:08 2038
2147483649, Tue Jan 19 03:14:09 2038
2147483650, Tue Jan 19 03:14:10 2038
ppk@raspberrypi:~/DevOps/Y2K38 $ python ./test_year2k38.py
Current UTC time = 2024-02-20 16:47:32.554798
Current Local time = 2024-02-20 08:47:32.555069
Last time that can be stored on 32 bit os 2038-01-18 19:14:07
Next Second on 64 bit OS 2038-01-18 19:14:08
ppk@raspberrypi:~/DevOps/Y2K38 $ perl ./test_year2k38.pl
Tue Jan 19 03:14:06 2038
Tue Jan 19 03:14:07 2038
Tue Jan 19 03:14:08 2038
Tue Jan 19 03:14:09 2038
Tue Jan 19 03:14:10 2038
Last time in seconds that can be stored on a 32 bit machine 2147483647
Last day on 32/64 bit Tue Jan 19 03:14:07 2038
Current time on 32 bit/64 bit Tue Jan 19 03:14:07 2038

Next time after a second increment on 32 bit/64 bit Tue Jan 19 03:14:08 2038
```