MIDI Protocol

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Bytes

MIDI protocol and MIDI files are based on bytes

Bytes

- Bytes are 8-digit binary digits (states)

00000000 — 11111111

bit = Binary digIT

- Total number of configurations of the 8 digits:

2^8= 256

- Representing as an unsigned integer:

0 — 255

- Representing as a 2's compliment signed integer (still 256 states):

0 — 127, -128 — -1

Positional notation of numbers

https://en.wikipedia.org/wiki/Positional_notation

- What does “365” mean?

Positional notation of numbers

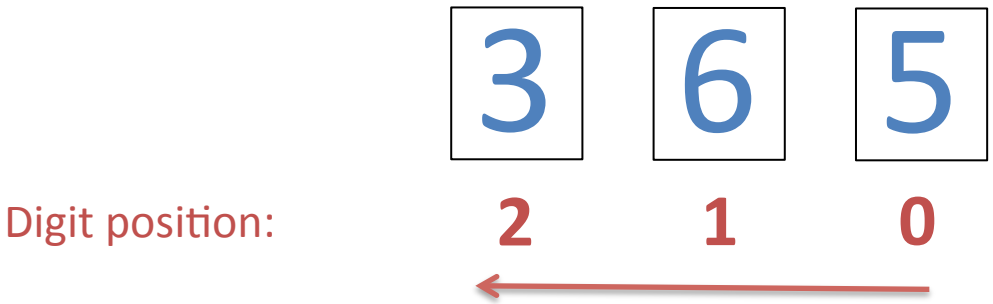
https://en.wikipedia.org/wiki/Positional_notation

- What does "365" mean?

$$365 = 300 + 60 + 5$$

$$365 = 3 \times 100 + 6 \times 10 + 5 \times 1$$

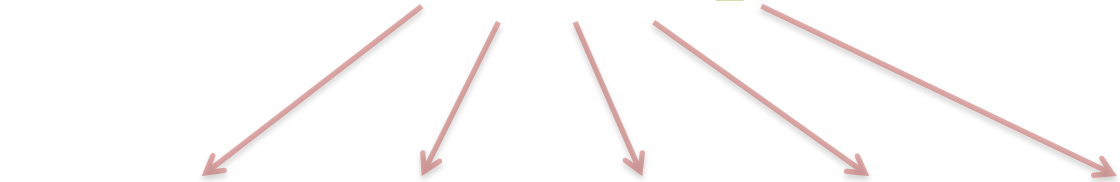
$$365 = 3 \times 10^{2} + 6 \times 10^{1} + 5 \times 10^{0}$$



Binary Numbers

What is the binary number 10110 in decimal positional notation (base-10)?

$$10110_2$$



$$1x2^4+0x2^3+1x2^2+1x2^1+0x2^0$$

$$16 + 0 + 4 + 2 + 0$$

$$22_{10}$$

Hexadecimal Numbers

- Hexadecimal uses **16** as the positional base.

- Digits representing “10” through “15” are the letters “A” through “F”

$A_{16} = 10_{10}$ $D_{16} = 13_{10}$

$B_{16} = 11_{10}$ $E_{16} = 14_{10}$

$C_{16} = 12_{10}$ $F_{16} = 15_{10}$`

Hex vs Binary vs Decimal

- Computers operate internally with binary (on/off states)
- Converting 01101010_2 to decimal is non-trivial (add lots of powers of two)
- Converting 01101010_2 to hexadecimal is trivial (memorize 16 conversions) because every four binary digits represent one hex digit ("nibble").

01101010_2 :

01101010_2

0110 1010

4+2 8+2

6 A

$6A_{16}$

01101010_2

64+32+8+2

106_{10}

Useful Conversion to Know

$11111111_2 = FF_{16} = 255_{10}$

2's compliment interpretation: $= -1_{10}$

$01111111_2 = 7F_{16} = 127_{10}$

$10000000_2 = 80_{16} = 128_{10}$

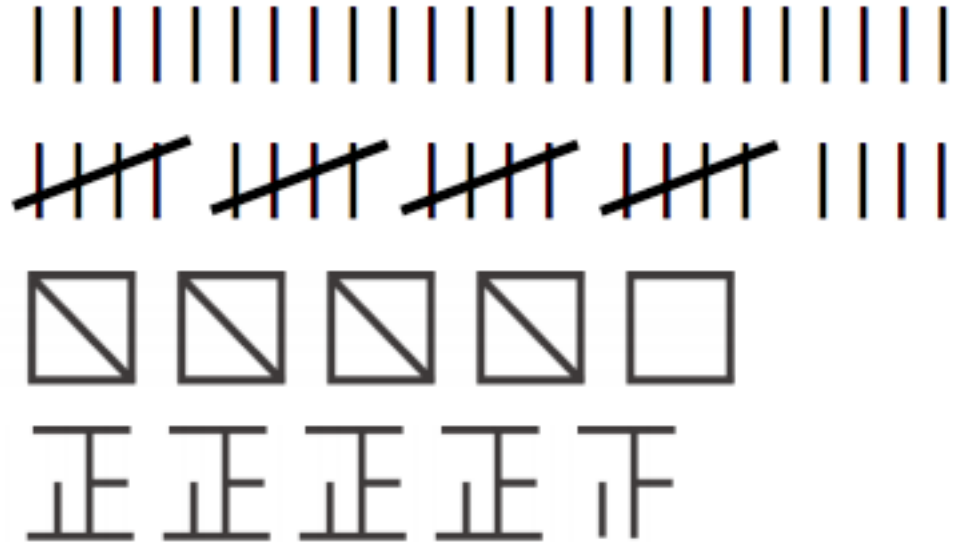
Note: FF**h** and **0x**FF are alternate ways of indicating hex.

Other Positional Bases

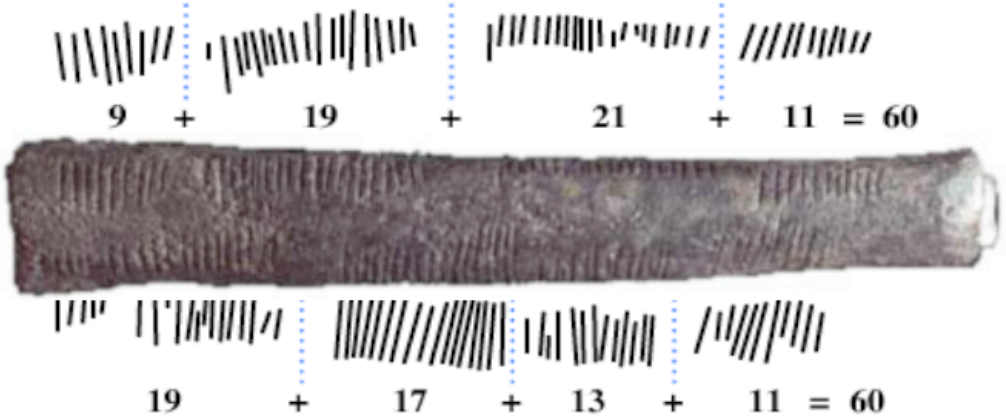
http://wiki.ccarh.org/images/9/92/Hexadecimal_numbers.pdf

Tally marks (base-1):

24



Ishango bone ~20,000 years old www.wikipedia.org/wiki/Ishango_bone

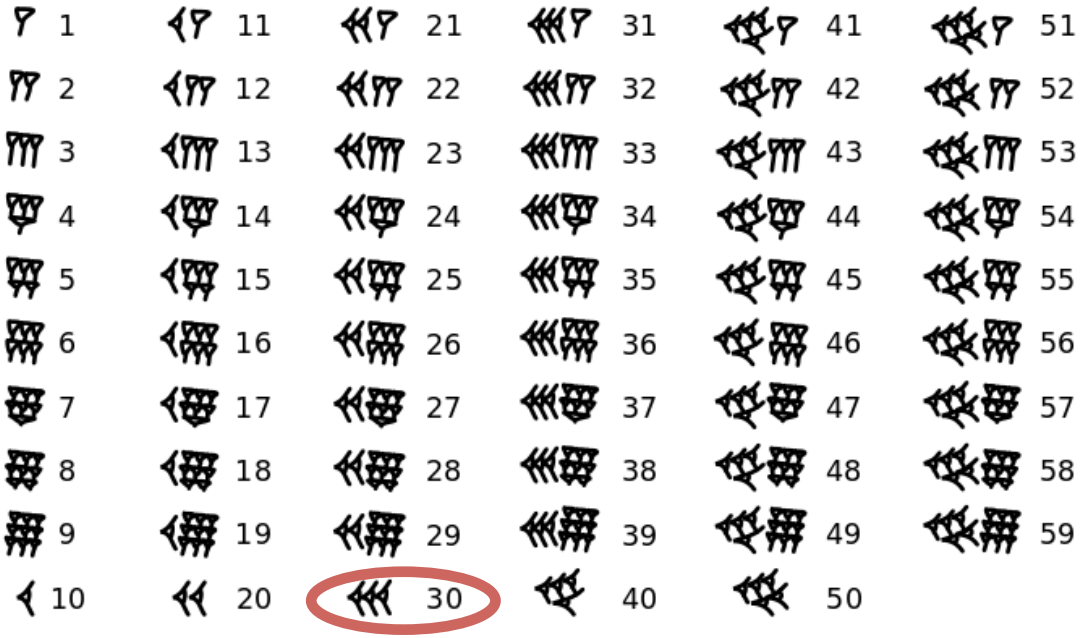


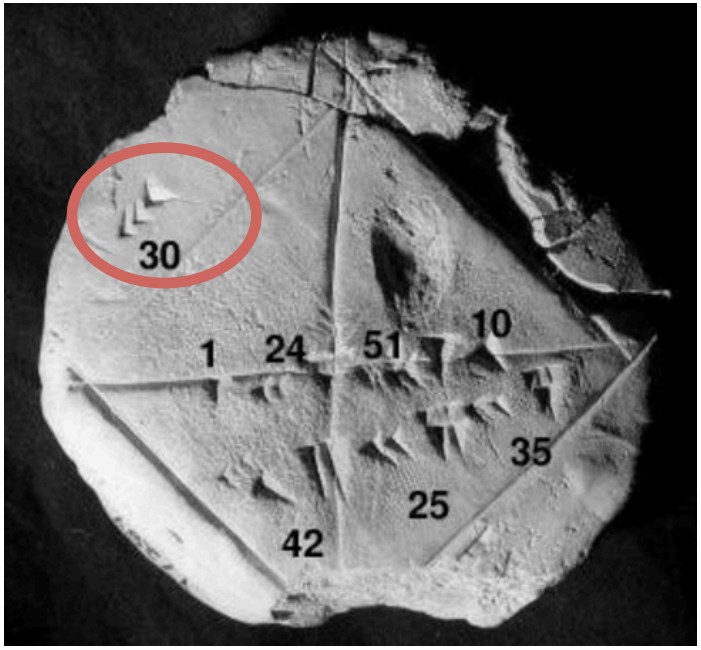
Sexagesimal (Base-60)

https://en.wikipedia.org/wiki/Sexagesimal

Developed ~5000 years ago by Sumerians

(c. 1800–1600 BCE)





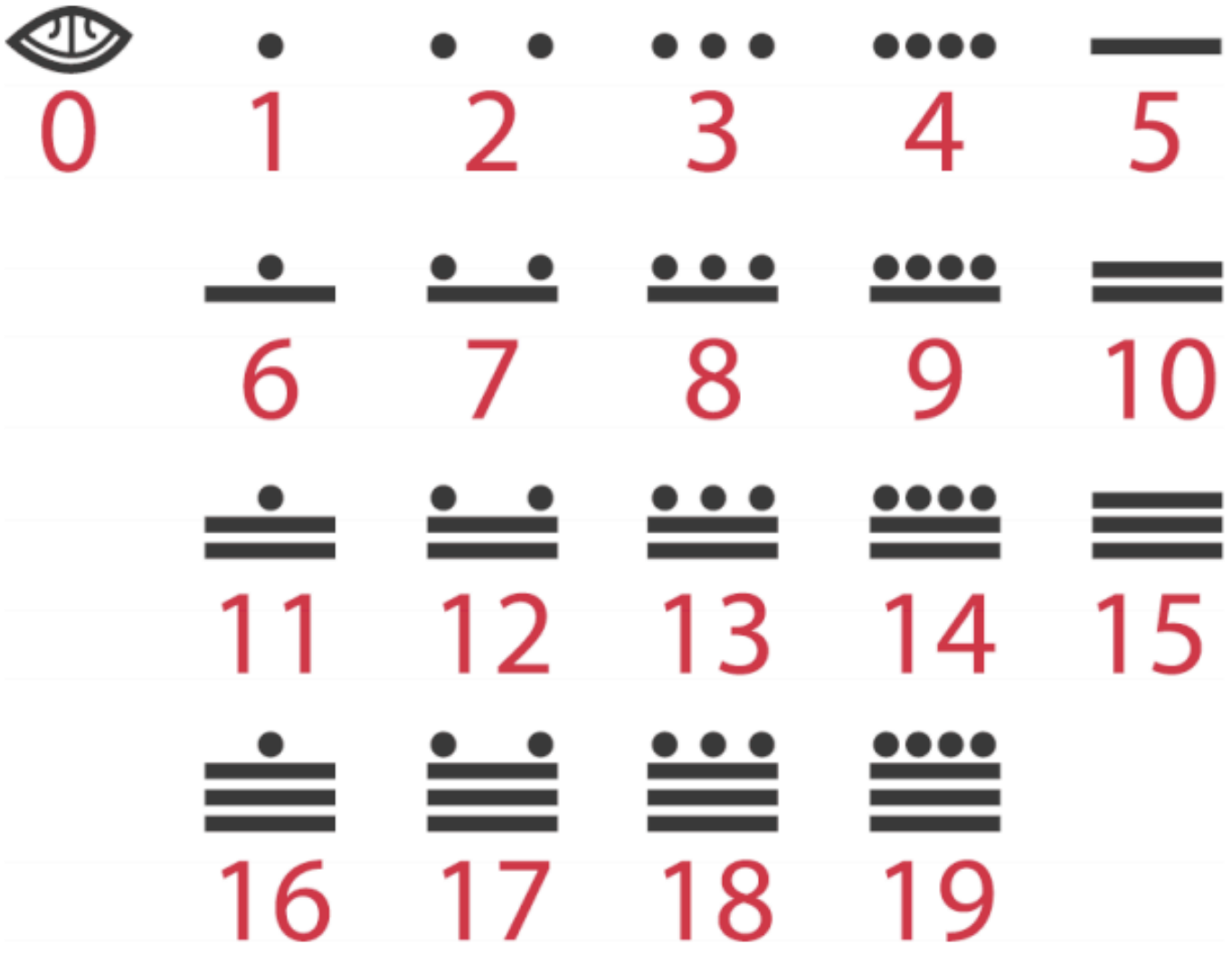
$1;24,51,10 = 1 + 24/60^1 + 51/60^2 + 10/60^3$

$= 1.41421296 \approx \sqrt{2}$

Minutes/Seconds:

12’3’’ + 16’42” = 20’12”

Mayan Numbers (Base-20)



Mayan Numbers (2)

$3 \times 20^2 = 1200$

$0 \times 20^1 = 0$

$18 \times 20^0 = 18$

1218

http://www.mayacalendar.com/mayacalendar/f-mayamath.html

MIDI Bytes

MIDI Data/Command Bytes

0 — 127

128 — 255

Data bytes

Command bytes

10000000_2 — 01111111_2

80h — FFh

00000000_2 — 01111111_2

00h — 7Fh

7-BITS

MIDI Commands

8_	Note-off	C_	Patch change
9_	Note-on	D_	Channel Pressure
A_	Aftertouch	E_	Pitchbend
B_	Continuous controller	F_	System messages

MIDI Command Parameters

= data byte (number between 0 and 127)

Note-off	8_	key	velocity	Patch change	C_	instrument	
Note-on	9_	key	velocity	Channel pressure	D_	pressure	
Aftertouch	A_	key	pressure	Pitchbend	E_	LSB	MSB
Continuous controller	B_	controller	value	System messages	F_	(usually 0 except sysex)	

Running Status

REGULAR MESSAGING:

90 3C 48 91 3E 52 91 3E 00 90 3C 00

RUNNING STATUS (remove repeated command bytes):

90 3C 48 91 3E 52 3E 00 90 3C 00

Reconstructing regular messages

90 3C 48 91 3E 52 (91) 3E 00 90 3C 00

Alternate Note-Off Commands

8_ commands are for note-off messages:

80 3C 64 = turn off note 60 (0x3C, middle C)
With a release velocity of 100 (64h)

But also a common note-off shorthand:

90 3C 00 = turn off note 60 (0x3C, middle C)
With undefined release velocity

- So softest sounding note has data byte of 01, not 00.

Cinmidi

http://wiki.ccarh.org/wiki/Cinmidi

"Console-In MIDI": Display incoming MIDI messages in terminal with timestamps.

```
;;
;; Style:           default
;; Timing:          delta milliseconds
;; Message format: delta-time, MIDI command-byte, MIDI parameter-byte(s)
;; Format:          asciimidi 1.0
;; Command-line:    cinmidi -o invention13-28.txt -p 1
;; Input Port:      1:
;; Cpu Speed:       1000 MHz
;;

0       0x90  64  88            ; NOTE chan:1 key:E4 vel:88
30      0x80  45  64            ; NOTEOFF chan: 1 key:A2 vel: 64
128     0x90  69  88            ; NOTE chan:1 key:A4 vel:88
7       0x80  64  64            ; NOTEOFF chan: 1 key:E4 vel: 64
23      0x90  57  87            ; NOTE chan:1 key:A3 vel:87
109     0x90  72  91            ; NOTE chan:1 key:C5 vel:91
25      0x80  69  64            ; NOTEOFF chan: 1 key:A4 vel: 64
98      0x90  71  91            ; NOTE chan:1 key:B4 vel:91
4       0x80  72  64            ; NOTEOFF chan: 1 key:C5 vel: 64
102     0x80  71  64            ; NOTEOFF chan: 1 key:B4 vel: 64
28      0x90  64 104            ; NOTE chan:1 key:E4 vel:104
109     0x80  57  64            ; NOTEOFF chan: 1 key:A3 vel: 64
```