

MIDI Protocol

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Bytes

MIDI protocol and MIDI files are based on bytes

Bytes

- Bytes are 8-digit binary digits (on/off 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 complement 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

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- What does “365” mean?

$$365 = 300 + 60 + 5$$

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

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



Digit position:



Binary Numbers

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

$$10110_2$$
$$1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$

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

$$22_{10}$$

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: $= -1_{10}$

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

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

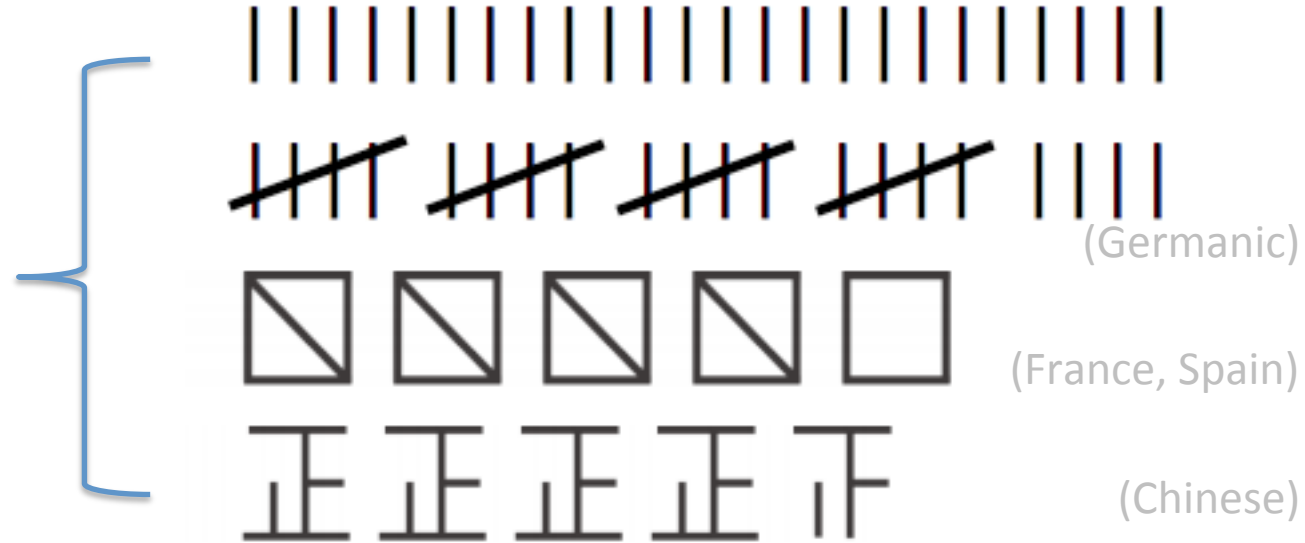
Note: FFh and 0xFF are alternate ways of indicating hex.

Other Positional Bases

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

Tally marks (base-1):

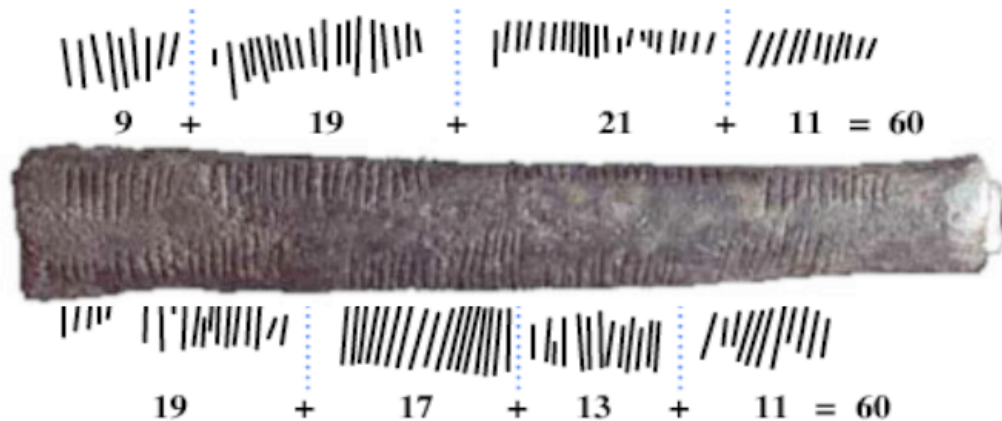
24



Ishango bone

~20,000 years old

www.wikipedia.org/wiki/Ishango_bone



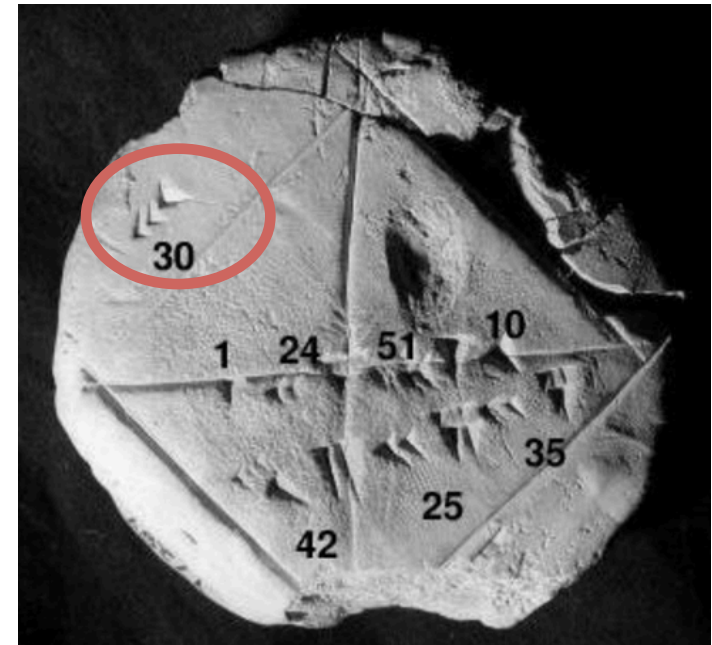
Sexagesimal (Base-60)

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

Developed ~5000 years ago by Sumerians

(c. 1800–1600 BCE)

𐎶 1	𐎠𐎺 11	𐎠𐎶𐎶 21	𐎠𐎶𐎶𐎶 31	𐎠𐎶𐎶𐎶𐎶 41	𐎠𐎶𐎶𐎶𐎶𐎶 51
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$$1;24,51,10 = 1 + 24/60^1 + 51/60^2 + 10/60^3$$

$$= 1.41421296 \approx \sqrt{2}$$

Minutes/Seconds:

$$12'30'' + 16'42'' = 29'12''$$

Mayan Numbers (Base-20)



0



1



2



3



4



5



6



7



8



9



10



11



12



13



14



15



16



17



18



19

Mayan Numbers (2)



$$3 \times 20^2 = 1200$$



$$0 \times 20^1 = 0$$



$$18 \times 20^0 = 18$$

1218

MIDI Bytes

MIDI Data/Command Bytes

0 — 127

128 — 255

Data bytes

Command bytes

00000000_2 — 01111111_2

00h — 7Fh

7-BITS

10000000_2 — 01111111_2

80h — FFh

MIDI Commands



8_

Note-off

C_

Patch change

9_

Note-on

D_

Channel Pressure

A_

Aftertouch

E_

Pitchbend

B_

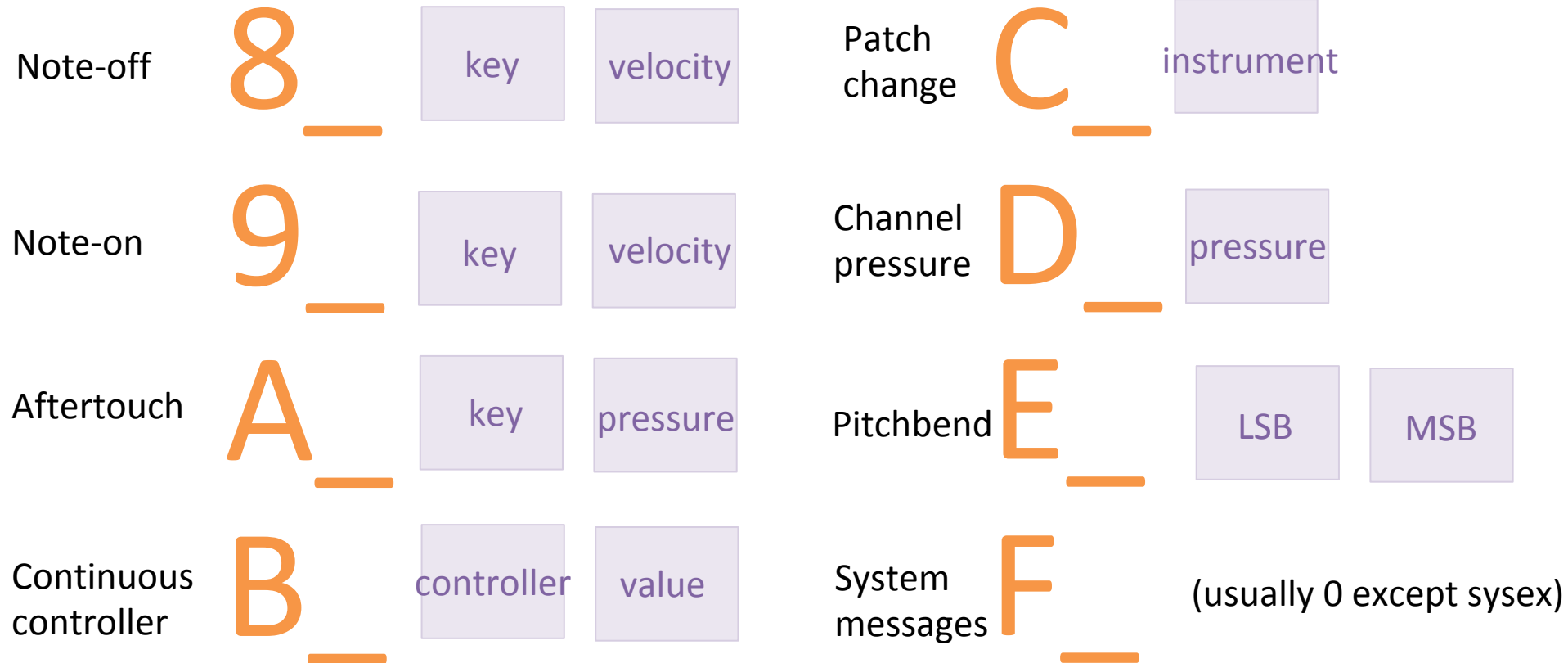
Continuous controller

F_

System messages

MIDI Command Parameters

 = data byte (number between 0 and 127)



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
```