Communication Protocols

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ENTI-UB

2018/2019

Outline

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MIDI - Description

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"MIDI (short for Musical Instrument Digital Interface) is a technical standard that describes a communications protocol, digital interface, and electrical connectors that connect a wide variety of electronic musical instruments, computers, and related audio devices[1]*."*

[1] https://en.wikipedia.org/wiki/MIDI

MIDI - Description

"MIDI (short for Musical Instrument Digital Interface) is a technical standard that describes a **communications protocol**, **digital interface**, *and* **electrical connectors** *that connect a wide variety of electronic musical instruments, computers, and related audio devices*[2]*."*

[2] https://en.wikipedia.org/wiki/MIDI

MIDI - History

Before MIDI...

- General incompatibility of audio hardware.
- Some "standards"...
  - CV/Gate: analog consequence of modular synths.
  - DCB (Digital Control Bus): Protocol by Roland.

MIDI - History

MIDI - History

- Itakuro Kakehashi (founder of Roland) started conversations with audio hardware companies in 1981.
- AES standard proposal discussion: Roland, Yamaha, Korg, Kawai and Sequencial Circuits.
- Official announcement by Moog in 1982 in the *Keyboard* magazine.
- First synths implementing MIDI: Roland Jupiter-6 and Sequencial Circuit Prophet 600 (1982)
- MIDI 1.0 specification published in 1983.

MIDI - History

"The creative possibilities brought about by MIDI technology are credited for helping revive the music industry in the 1980s"[3].

"MIDI revolutionized the music industry, and its continued use is a good measure of the success of the standard"[4].

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[3] Shuker, Roy. Understanding Popular Music. London: Routledge, 1994. p.286

[4] Phillips, Dave. An Introduction to OSC. Linux Journal. https://www.linuxjournal.com/content/introduction-osc

MIDI - Specifications

MIDI 1.0: Two specification levels:

- Hardware Transport
- Message Format

MIDI - Specifications

Hardware Transport

- Simplex (one way data transmission)
- Asynchronous serial
- Rate: 3.125 kBps
- 5-pin DIN connector

MIDI - Specifications

MIDI - Specifications

Message Format[5]

Different message types:

- Channel Voice
- Channel Mode
- System

[5] For more info check https://www.midi.org/specifications-old/item/table-1-summary-of-midi-message

MIDI - Specifications

Channel Voice Messages

- 7 bit value range (128 different values)
- 4 bit channel range (16 different channels)

- Note On / Note Off
- Control Change (CC)
- Program Change
- Pitch Bend Change
- Aftertouch

MIDI - Specifications

Channel Voice Messages

Note On / Note Off
[Channel Note Velocity]

- Start/end of single musical event
- Note range: C_{-1} to G_9, 8.176 to 12.544 Hz[6].
- Two implementations of note end:
  - *Note Off* message in a note previously activated by *Note On*
  - *Note On* message with 0 velocity

[6] Grand piano ranges 88 notes from A_0 to C_8.

MIDI - Specifications

Channel Voice Messages

Control Change
[Channel ControlNumber Value]

- Sends information about the value of a control
- Commonly used for sliders, knobs...
- Last 8 control number values are reserved (*Channel Mode Messages*)

MIDI - Specifications

Channel Voice Messages

Pitch Bend
[Channel Value]

- Changes **global** pitch in +-2 semitones
- Special resolution: 16384 values

MIDI - Specifications

Channel Voice Messages

Aftertouch (Note)
[Channel Note Value]

- Allows note expressivity (tremolo, vibrato)
- Not always implemented...

MIDI - Specifications

Channel Mode Messages

- 8 last control numbers of the CC message
- Special sound messages:
  - *All Sound Off*
  - *Reset All Controllers*
  - *Local Control*
  - *All Notes Off*
  - *Omni/Poly modes*

MIDI - Specifications

System Messages

Some non-musical message definitions:

- Manufacturer exclusive messages (*SysEx*)
- Playback transport
- Time Codes
- ...

MIDI - Specifications

Some drawbacks...

- Slow transmission rate
- Non-flexible music representation (biased towards 12 tone equal-temperament, western timing representation...)
- Designed for keyboards
- Insufficient numeric resolution in CC
- ...

... but still a successful technology (almost) 40 years after!

MIDI - Extensions

USB-MIDI[7]

- 5-pin DIN is nowadays not very popular...
- Implementation of MIDI as Audio Class-Compilant Profile
- USB is much faster: one connection might support up to 16 independent MIDI streams

[7] For more info check https://www.midi.org/articles-old/basic-of-usb

MIDI - Extensions

General MIDI

General MIDI is _NOT_ MIDI

MIDI - Extensions

General MIDI

- Sound specification for instruments responding to MIDI messages
- Attempt to standardize the sound produced by MIDI instruments/synths

MIDI - Extensions

General MIDI

Required features:

- 24 simultaneous voices
- Note velocity
- Usage of all 16 channels (channel 10 reserved for percussion)
- Polyphony

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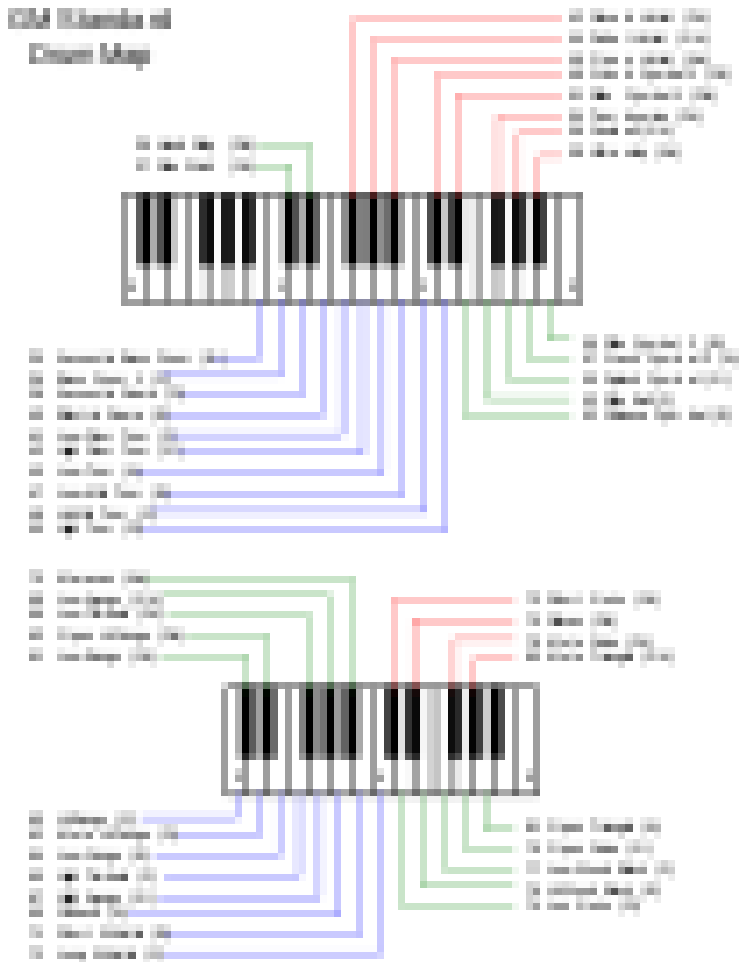
MIDI - Extensions

4-1- MAIN SOUNDS - GENERAL MIDI
(all channels except 10)

PC: Program change

PC	GENERAL MIDI	PC	GENERAL MIDI	PC	GENERAL MIDI	PC	GENERAL MIDI
1	(Grand) Piano 1	33	Acoustic Bass	65	Soprano Sax	97	FX 1 (rain)
2	(Bright) Piano 2	34	Finger Bass	66	Alto Sax	98	FX 2 (soundtrack)
3	(El. Grd) Piano 3	35	Picked Bass	67	Tenor Sax	99	FX 3 (crystal)
4	Honky-tonk Piano	36	Fretless Bass	68	Baritone Sax	100	FX4 (atmosphere)
5	El. Piano 1	37	Slap Bass 1	69	Oboe	101	FX 5 (brightness)
6	El. Piano 2	38	Slap Bass 2	70	English Horn	102	FX 6 (goblins)
7	Harpsichord	39	Synth Bass 1	71	Bassoon	103	FX 7 (echoes)
8	Clavi	40	Synth Bass 2	72	Clarinet	104	FX 8 (sci-fi)
9	Celesta	41	Violin	73	Piccolo	105	Sitar
10	Glockenspiel	42	Viola	74	Flute	106	Banjo
11	Music Box	43	Cello	75	Recorder	107	Shamisen
12	Vibraphone	44	Contrabass	76	Pan Flute	108	Koto
13	Marimba	45	Tremolo Strings	77	Blown Bottle	109	Kalimba
14	Xylophone	46	Pizzicato Strings	78	Shakuhachi	110	Bag pipe
15	Tubular Bells	47	Orchestral Harp	79	Whistle	111	Fiddle
16	Santur	48	Timpani	80	Ocarina	112	Shanai
17	Drawbar Organ	49	String Ensemble 1	81	Lead 1 (square)	113	Tinkle Bell
18	Percussive Organ	50	String Ensemble 2	82	Lead 2 (sawtooth)	114	Agogo
19	Rock Organ	51	Synth Strings 1	83	Lead 3 (calliope)	115	Steel Drums
20	Church Organ	52	Synth Strings 2	84	Lead 4 (chiff)	116	Woodblock
21	Reed Organ	53	Choir Aahs	85	Lead 5 (charang)	117	Taiko Drum
22	Accordion (french)	54	Voice Oohs	86	Lead 6 (voice)	118	Melodic Tom
23	Harmonica	55	Synth Voice	87	Lead 7 (fifths)	119	Synth Drum
24	Tango Accordion	56	Orchestra Hit	88	Lead8 (bass+lead)	120	Reverse Cymbal
25	Ac. Guitar (nylon)	57	Trumpet	89	Pad 1 (fantasia)	121	Gt. Fret Noise
26	Ac. Guitar (steel)	58	Trombone	90	Pad 2 (warm)	122	Breath Noise
27	El. Guitar (jazz)	59	Tuba	91	Pad 3 (polysynth)	123	Seashore
28	El. Guitar (clean)	60	Muted Trumpet	92	Pad 4 (choir)	124	Bird Tweet
29	El. Guitar (muted)	61	French Horn	93	Pad 5 (bowed)	125	Teleph. Ring
30	Overdriven Guitar	62	Brass Section	94	Pad 6 (metallic)	126	Helicopter
31	Distortion Guitar	63	Synth Brass 1	95	Pad 7 (halo)	127	Applause
32	Guitar harmonics	64	Synth Brass 2	96	Pad 8 (sweep)	128	Gunshot

MIDI - Extensions



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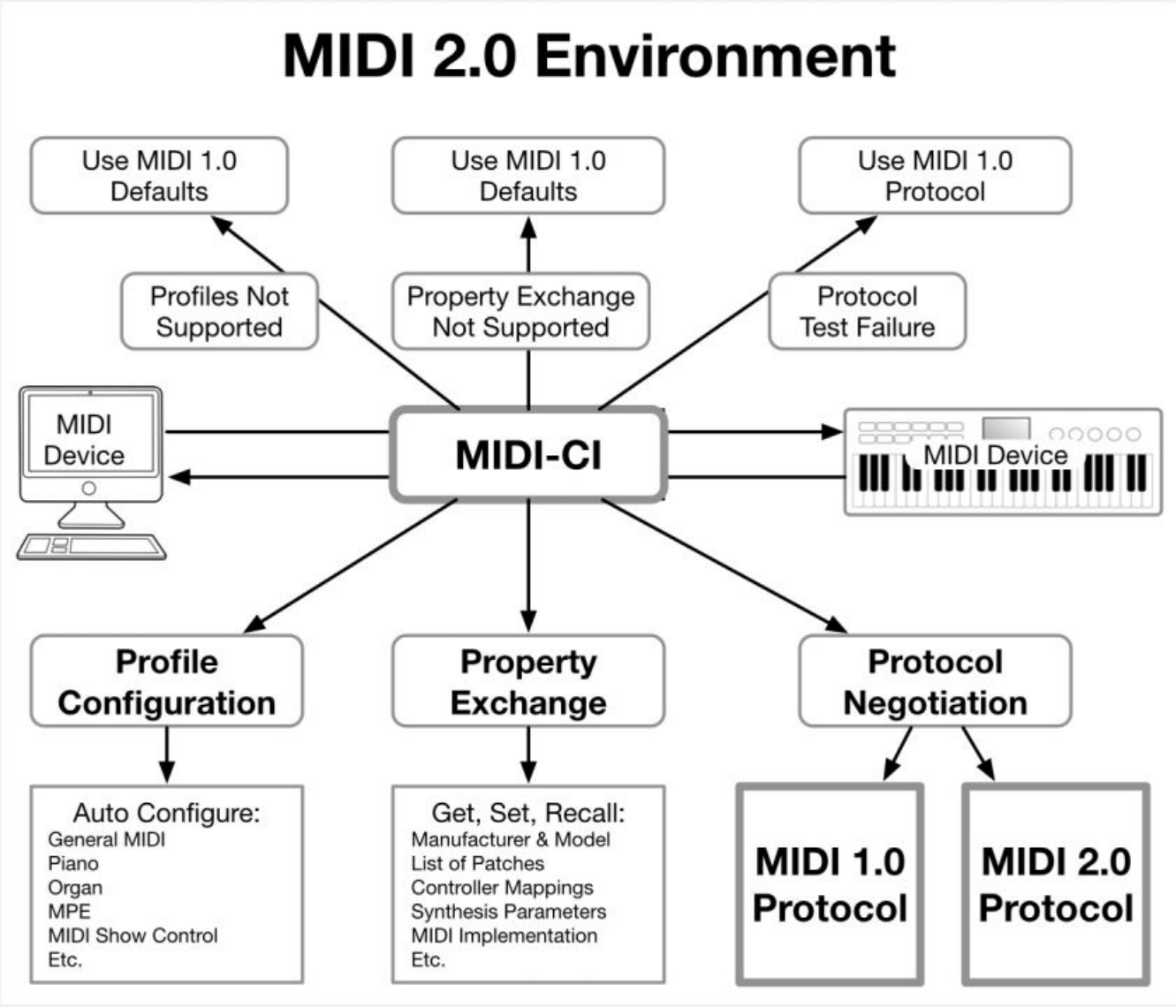
MIDI - Extensions

MIDI 2.0[8]

- Extends limitations of MIDI 1.0
- Backwards-compatible
- Announced in January 2019
- Industry standard: Ableton/Cycling '74, Art+Logic, Bome Software, Google, imitone, Native Instruments, Roland, ROLI, Steinberg, TouchKeys, and Yamaha

[8] For more info check https://www.midi.org/articles-old/the-midi-manufacturers-association-mma-and-the-association-of-music-electronics-industry-amei-announce-midi-2-0tm-prototyping

MIDI - Extensions



Outline

OSC - Description

Open Sound Control (OSC) is a protocol for communication among computers, sound synthesizers, and other multimedia devices that is optimized for modern networking technology. Bringing the benefits of modern networking technology to the world of electronic musical instruments, OSC's advantages include interoperability, accuracy, flexibility, and enhanced organization and documentation[9].

[9] http://opensoundcontrol.org/introduction-osc

OSC - Description

Features[10]:

- Open-ended, dynamic, URL-style symbolic naming scheme
- Symbolic and high-resolution numeric argument data
- Pattern matching language to specify multiple recipients of a single message
- High resolution time tags
- "Bundles" of messages whose effects must occur simultaneously
- Query system to dynamically find out the capabilities of an OSC server and get documentation

[10] http://opensoundcontrol.org/introduction-osc

OSC - Specifications

Atomic data types:

- int32: 32 bit fixed-point
- OSC-timetag: 64 bit fixed-point
- float32: 32 bit IEEE 754 floating-point
- OSC-string: ASCII character
- OSC-blob: arbitrary binary data

OSC - Specifications

OSC Message:

- OSC Address: string starting with '/'
- OSC Type Tag: character representing the data type sent
- OSC Argument: actual values sent, interpreted by the type tags

OSC Bundle

- OSC Time Tag
- OSC Bundle Element: any OSC Message or OSC Bundle

OSC - Specifications

OSC Message examples:

- /this/is/an/OSC/message
- /synth/1/gain, 0.5
- /foo/bar, 1, 'asdf', 3.141592

OSC - Specifications

So... where is the sound?

- OSC is in fact not a protocol in the same sense as MIDI, but rather a *content format*.
- That means that **there is not** a standard way of expressing sound/music information[11].
- OSC just unifies how to send data between applications, but not how this data looks like...

[11] Despite there have been some attempts... https://github.com/fabb/SynOSCopy/wiki

OSC - Specifications

- OSC is a popular data sharing protocol in multimedia applications.
  - DAWS: Logic, Reaper, Ardour, Traktor...
  - Sound programming languages: Max/MSP, Pure Data, SuperCollider, Sonic Pi...
  - Graphics: Blender, OpenFrameworks, UnrealEngine, Processing...
  - Hardware Controllers: Monome, Lemur...
- OSC and MIDI are not direct competitors![12]

[12] Interesting reading: https://www.midi.org/articles-old/white-paper-comparison-of-midi-and-osc