COSC 4P98 Lecture notes: **MIDI**
October 23, 2017
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- MIDI: Musical Instrument Digital Interface
    - specification is available online at www.midi.org
- invented in 1983 by consortium of instrument manufacturers
- basically an asynchronous serial network protocol
- signals are musical events: note on/off messages ("piano roll")
- midi is to audio waves, as a script is to a movie
- there is no sound data in a MIDI file
    - this explains why midi files of songs are small and compact compared to MP3/WAVE files
- Uses:
    - separate the input device (keyboard) from the sound generator
    - one keyboard can play many MIDI instruments
    - novel controllers: different interfaces
        - eg. keyboard, breath controller, microphone, jello,…
    - software on computers can generate MIDI to control instruments
    - keyboard playing can be recorded via MIDI software
    - device-independent software and compositional environments
    - can use MIDI to communicate with particular hardware (device dependent librarians, controllers)
    - can control other audio devices: effects boxes, mixers, lights,...
    - can control computer animation!
    - transfer music between devices and software
- Physical characteristics:
    - 31.25 baud (31,250 bits/sec = 0.03 Mbits/sec = 0.00003 Gb/sec)
        - compare:  USB 1: 12 Mbits/ sec
        - USB 2: 480 Mbits/sec
        - Firewire 800: 786 Mbits/sec
        - USB 3.1: 10 Gb/sec
        - Thunderbolt 3: 40 Gbits/sec
        - sampling rates: 44k samples/sec at 16 bits/sample = 0.7 Mbits/sec
        - → MIDI rate is more than adequate for keyboard playing, but can't handle real-time sampling.
    - 5-pin DIN plug, 50 foot cable maximum (otherwise delay or latency, signal "skew")
        - However, USB is now used as physical medium, with MIDI software protocol is communication language
        - overcomes latency problems, plus USB is cheap and ubiquitous
    - plugs in traditional MIDI instruments:
        - IN = control instrument
        - OUT = record (or control other instruments)

- o THRU = pass IN to other instruments
- Idea is to daisy-chain instruments together
  - but # instruments, and length of total connection, are important!
- Software characteristics
  - asynchronous serial protocol
  - 16 channels: 16 instruments, or 16 logical data streams in 1 instrument (or combination of both)
  - each channel is a stream of data, labeled to go on that channel number
  - if you need more than 16 channels (and most instruments do), you then need to use multiple midi ports (or modes)
  - Messages format:
    - o 1 byte data words, with start and stop bits: 10 bits

    eg:  <u>NOTE</u> <u>CHAN</u>          <u>KEY #</u>          <u>Velocity</u>

      ON    1              60 (mid. C)    116

    - o pitch is therefore a key #, mapped by instrument to keyboard key
    - o pitch is NOT a frequency!
    - o velocity: value between 0 and 255
    - o but instrument can interpret velocity any way it wants… loudness? brightness? timbre? etc.

  - Other messages:
    - o OFF        1      60      40
    - o ALL NOTES OFF (turns off all "on" notes on the instrument)
    - o aftertouch: finger pressure on key while note is being played
    - o continuous controller change: pitch bend wheel (expression)
    - o song: select position in a MIDI stream (resident in memory)
    - o MIDI clock: pulse to sequence (multiple) instruments with each other, and computer
    - o System exclusive (SYSEX): protocol for manufacturers to send device-specific messages
      - a "hack" or catch-all for miscellaneous communications
      - can be used to send sample data to/from samplers (but not in real-time)
  - Note that MIDI is used for real-time communication, as well as file storage
    - o very similar, except that file is static, and hence timing information must be explicitly denoted (duration between events)
    - o see "midi file specification" at www.midi.org
- MIDI application software
  - DAW: digital audio workstation
    - o MIDI, plus audio sampling/playback
  - commercial sequencers: Logic Pro X, Cubase, Ableton, ProTools, Fruityloops,…

- o "sequencer": sequence the notes (music events)
- o many automatically transcribe into music notation as well
- o early programs were exclusively MIDI
- o but advent of affordable, high-quality digital audio cards meant that audio processing was introduced
- o most programs mix audio and MIDI
  - however, both are still separate data streams
- o programming language interfaces exist: Java, Python, Processing,...
- o Specialized applications: pitch detection, algorithmic composition environments, others
- o Software has essentially replaced hardware in terms of functionality; but many musicians still prefer hardware interfaces, plus stand-alone instruments.
  - software is still more powerful, easier to update, and much cheaper.
- VST: Steinberg's Virtual Studio protocol
  - a programming interface that lets 3rd party developers extend commercial software visaviz "plug-ins"
  - Some plug-ins are as commercially successful and expensive as the host sequencers.
  - a whole industry exists around VST (and Digidesign's RTAS, which is similar)
  - more on VST later.
- Future: MIDI 2.0 (aka HD-MIDI)
  - Still in the works. It has been discussed for at least a decade.
  - Back compatible with MIDI 1.0, but not a replacement because MIDI is cost effective.
  - a high definition HD-MIDI
    - o Midi 1 has 127 levels... too coarse.
    - o Will support 1000's levels, high number devices, many parameters,...
  - 1000's of channels.
  - Rumoured support for
    - o plug-and-play connectivity with USB, Ethernet (wireless?)
    - o audio-video bridging
  - Hopefully it will also include audio data information
  - It might be a software protocol only. It doesn't need to address hardware issues (besides wireless and networking); USB is an accepted standard.
- A related technology: DMX512 (or DMX)
  - digital protocol for controlling stage lighting and FX
  - Since FX are often synchronized to music, there are MIDI-to-DMX converters.
  - Like midi, there is a HW and SW specification.
- Finally, besides DAW software used by musicians and DJs, there is also video mixing software
  - Often integrates with MIDI.

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- programmer-side: Processing, Pure Data, MAX/MSP (integrates with Ableton Live)
- commercial: Notch, ArcKaos, many more

**Bibliography**

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