Go 💖 MIDI

Exploration of Linux's System Interfaces

Tracks

0. Presentation Header
1. MIDI and SMF
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Track 1:
MIDI and SMF

Musical Instrument Digital Interface

- Protocol and Electrical standard for connecting musical instruments, computers, and related audio devices
- Defined in 1983, continues to be in active use
- Baud rate: 31250
- Supports up to 16 channels multiplexed
- Commands to trigger notes, no audio data is transmitted

Live Messages

- Channel Messages
    - Voice (note on/off, key pressure, pitch bends, bank select)
    - Mode (silence, polyphonic, monophonic)
- System Messages
    - Real Time (clock, start/stop, reset)
    - Common (MIDI timing code, song select)
    - Exclusive (stream of bytes)

Standard MIDI Files

- Set of instructions for MIDI devices
  - Sequencers, DAW, video games
- Storages messages along with their position
- Versions
  - Single track
  - Multitrack synchronous
  - Multitrack asynchronous
- Sounds only as good as the hardware synthesizing

SMF Messages

- Meta Messages
  - Sequence and track names, copyrights, lyrics
  - Time signature, tempo, key
- Channel Messages
- System Common and Exclusive Messages

BREAKING NEWS BREAKING NEWS BREAKING NEWS

MIDI 2.0

- Draft announced January 2019
- Increased resolution (8-bit to 32-bit in many cases)
- Supports up to 256 channels
- Backwards compatible

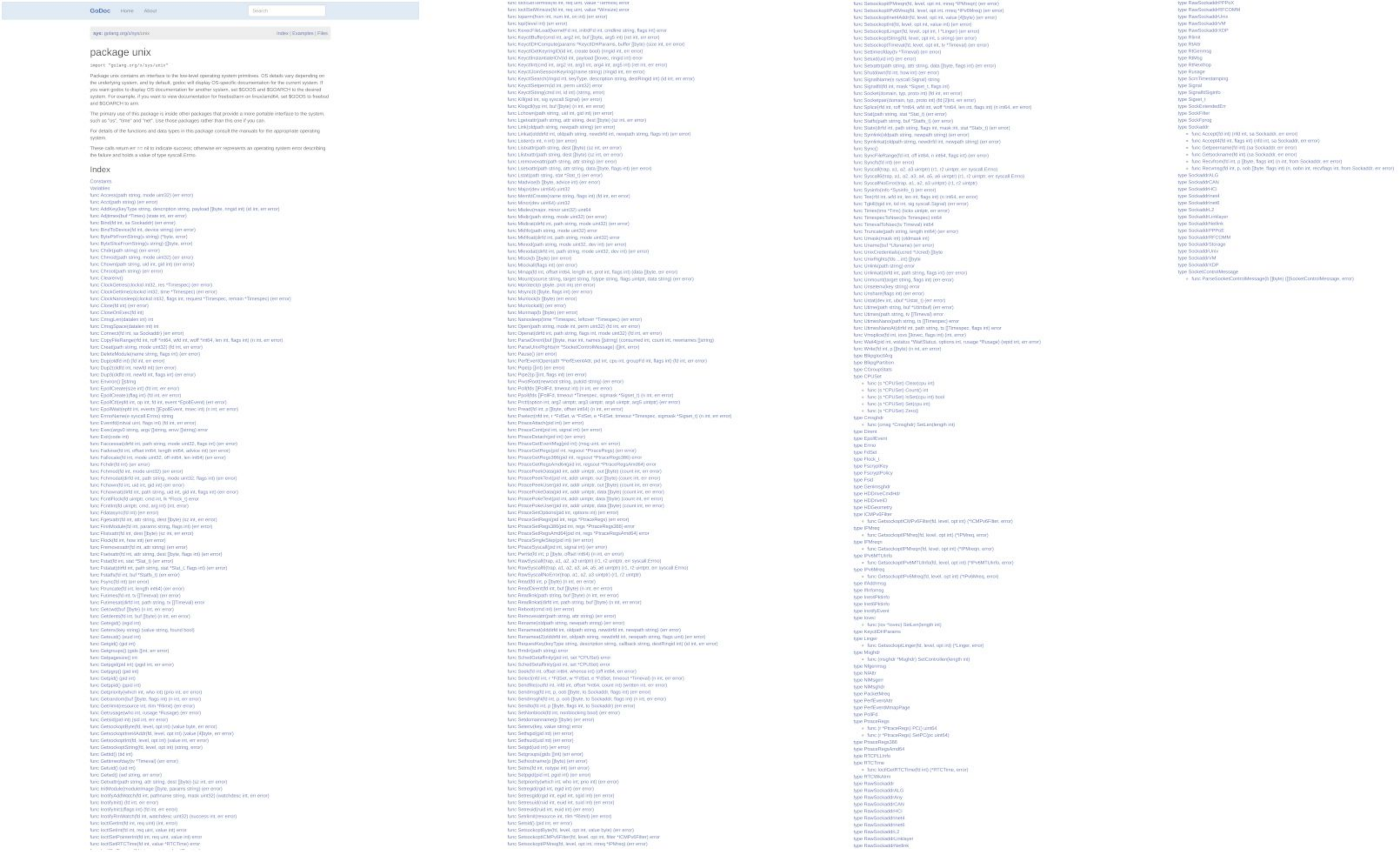
Track 2:
Linux

gokrazy

- Pure-Go Linux userland for applications
  - Small init written in Go
  - No C runtime
- `gokr-packer` CLI tool to build the distribution, including our Go applications

Syscall

- Directly make function calls into the kernel
- A lot of functionality is exposed!



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package unix

```
import "golang.org/x/sys/unix"
```

Package unix contains an interface to the low-level operating system primitives. OS details vary depending on the underlying system, and by default, godoc will display OS-specific documentation for the current system. If you want godoc to display OS documentation for another system, set $GOOS and $GOARCH to the desired system. For example, if you want to view documentation for freebsd/arm on linux/amd64, set $GOOS to freebsd and $GOARCH to arm.

The primary use of this package is inside other packages that provide a more portable interface to the system, such as "os", "time" and "net". Use those packages rather than this one if you can.

For details of the functions and data types in this package consult the manuals for the appropriate operating system.

These calls return err == nil to indicate success; otherwise err represents an operating system error describing the failure and holds a value of type syscall.Errno.

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- func (s *CPUSet) Count() int
- func (s *CPUSet) IsSet(cpu int) bool
- func (s *CPUSet) Set(cpu int)
- func (s *CPUSet) Zero()

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type Errno
type FdSet
type Flock_t
type FscryptKey
type FscryptPolicy
type Fsid
type Genlmsghdr
type HDDriveCmdHdr
type HDDriveID
type HDGeometry
type ICMPv6Filter
- func GetsockoptICMPv6Filter(fd, level, opt int) (*ICMPv6Filter, error)

type IPMreq
- func GetsockoptIPMreq(fd, level, opt int) (*IPMreq, error)

type IPMreqn
- func GetsockoptIPMreqn(fd, level, opt int) (*IPMreqn, error)

type IPv6MTUInfo
- func GetsockoptIPv6MTUInfo(fd, level, opt int) (*IPv6MTUInfo, error)

type IPv6Mreq
- func GetsockoptIPv6Mreq(fd, level, opt int) (*IPv6Mreq, error)

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- func Recvmsg(fd int, p, oob []byte, flags int) (n, oobn int, recvflags int, from Sockaddr, err error)

type SockaddrALG
type SockaddrCAN
type SockaddrHCI
type SockaddrInet4
type SockaddrInet6
type SockaddrL2
type SockaddrLinklayer
type SockaddrNetlink
type SockaddrPPPoE
type SockaddrRFCOMM
type SockaddrStorage
type SockaddrUnix
type SockaddrVM
type SockaddrXDP
type SocketControlMessage
- func ParseSocketControlMessage(b []byte) ([]SocketControlMessage, error)

golang.org/x/sys/unix

```
func Syscall(trap, a1, a2, a3 uintptr) (r1, r2 uintptr, err
syscall.Errno)
```

```
func Syscall6(trap, a1, a2, a3, a4, a5, a6 uintptr) (r1, r2
uintptr, err syscall.Errno)
```

```
func SyscallNoError(trap, a1, a2, a3 uintptr) (r1, r2 uintptr)
```

And a bunch of wrapping functions to deal with architecture differences

Memory Backed File

- Option 1: Create a temporary file on /tmp
  - Program or user might not have permissions to write to this directory
  - Directory isn't guaranteed to exist
  - Harder to track memory usage
  - Must remember to remove the file after use

Memory Backed File

- Option 2: Ask the Linux Kernel to create a file backed by memory
  - Kernel automatically clears the memory when all references to the file are closed
- `func MemfdCreate(name string, flags int) (fd int, err error)`
  - Create a file descriptor backed by memory
- `func Ftruncate(fd int, length int64) (err error)`
  - Truncate the file to the size of our data
- `func Mmap(fd int, offset int64, length int, prot int, flags int) (data []byte, err error)`
  - Map the memory of the file into our memory space

ioctl

Interact with special devices

```
cmd := ethtool_cmd{cmd: 0x00000001} // ETHTOOL_GSET
dev := []byte{"eth0"}
ifr := ifreq{name: uintptr(unsafe.Pointer(&dev[0])), data: &cmd}
f, _ := unix.Socket(unix.AF_INET, unix.SOCK_STREAM, 0)
_, _, errno := syscall.Syscall(unix.SYS_IOCTL, uintptr(f.Fd()),
         uintptr(unix.SIOCETHTOOL), uintptr(unsafe.Pointer(&ifr)))
```

Sockets

Similar to ioctl, passing structures between Go and Linux

```
info := iptGetInfo{name: []byte{"nat"}}
f, _ := unix.Socket(unix.AF_INET, unix.SOCK_RAW, unix.IPPROTO_RAW)
_, _, err := syscall.Syscall6(unix.SYS_GETSOCKOPT,
       uintptr(f.Fd()), uintptr(unix.IPPROTO_IP), uintptr(64),
       uintptr(unsafe.Pointer(&info)),
       unsafe.Sizeof(iptGetInfo), 0)
fmt.Printf("table has %d entries.\n", info.numEntries)
```

Problems

- The previous ways of interacting with the kernel rely on passing memory.
- Fine for small values, but annoying for structs.

Linux Netlink

- An IPC mechanism enabling communication between kernel and userspace (or between multiple userspace programs)
- Netlink communications never leave the local host
- Body of Netlink messages are encoded as list of attributes (Length, Type, Value)
    - Attributes may be nested in Values
    - Value is 4-byte aligned
- Bus for each family of messages

github.com/mdlayher/netlink

- Attribute Encoder and Decoders
- Creates and manages underlying sockets
- Manages sequence IDs for you :)

Generic Netlink

- Make it easier for kernel modules to support Netlink, a generic bus was defined, with its own families.
- Attributes of a Generic Netlink family
  - ID (change with every reboot, must look up)
  - Name
  - Version
  - Multicast group

github.com/mdlayher/genetlink

- Helps creates valid Netlink messages for the Generic Netlink family

Getting WiFI interfaces

```
c, err := genetlink.Dial(nil)
family, err := c.GetFamily(name)
req := genetlink.Message{
    Header: genetlink.Header{
        Command: nl80211CommandGetInterface,
        Version: family.Version,
    },
}
flags := netlink.HeaderFlagsRequest | netlink.HeaderFlagsDump
msgs, err := c.Execute(req, family.ID, flags)
```

Parsing Interface fields

```
func (ifi *Interface) parseAttributes(attrs []netlink.Attribute)
error {
    for _, a := range attrs {
        switch a.Type {
        case nl80211.AttrIfindex:
            ifi.Index = int(nlenc.Uint32(a.Data))
        case nl80211.AttrIfname:
            ifi.Name = nlenc.String(a.Data)
    }

    return nil
}
```

Aside to Desktop Linux

- A userspace daemon would listen to these events
    - Apply policies
    - Create symlinks on devtmpfs
    - Maintain device metadata and emit enriched events
- systemd, eudev, vdev
    - Maintain /run directories of metadata
    - Emit enriched events to dbus
- (optionally) Another daemon farther process these events
    - Udisks2 listens on dbus, and exposes RPCs specifically for working with disks
    - Udevil automatically mounts disks by listening to udev events

uevent and kobject

- Linux creates and manages kobjects that tracks the addition, modification, and removal of devices
- Changes to the kobject result in uevents passed from the kernel to userspace over a netlink family
- The values for the last uevent are exposed by Linux as a file in sysfs

github.com/mdlayher/kobject

```
c, _ := kobject.New()
for {
    event, _ := c.Receive()
    // process event
}
```

Coldplug

- uevent has no buffering, only new events
- Can process existing events by walking sysfs
  - filepath.Walk("/sys", filepath.WalkFunc)
  - Read "uevent" file
  - Parse key-value pair from each line

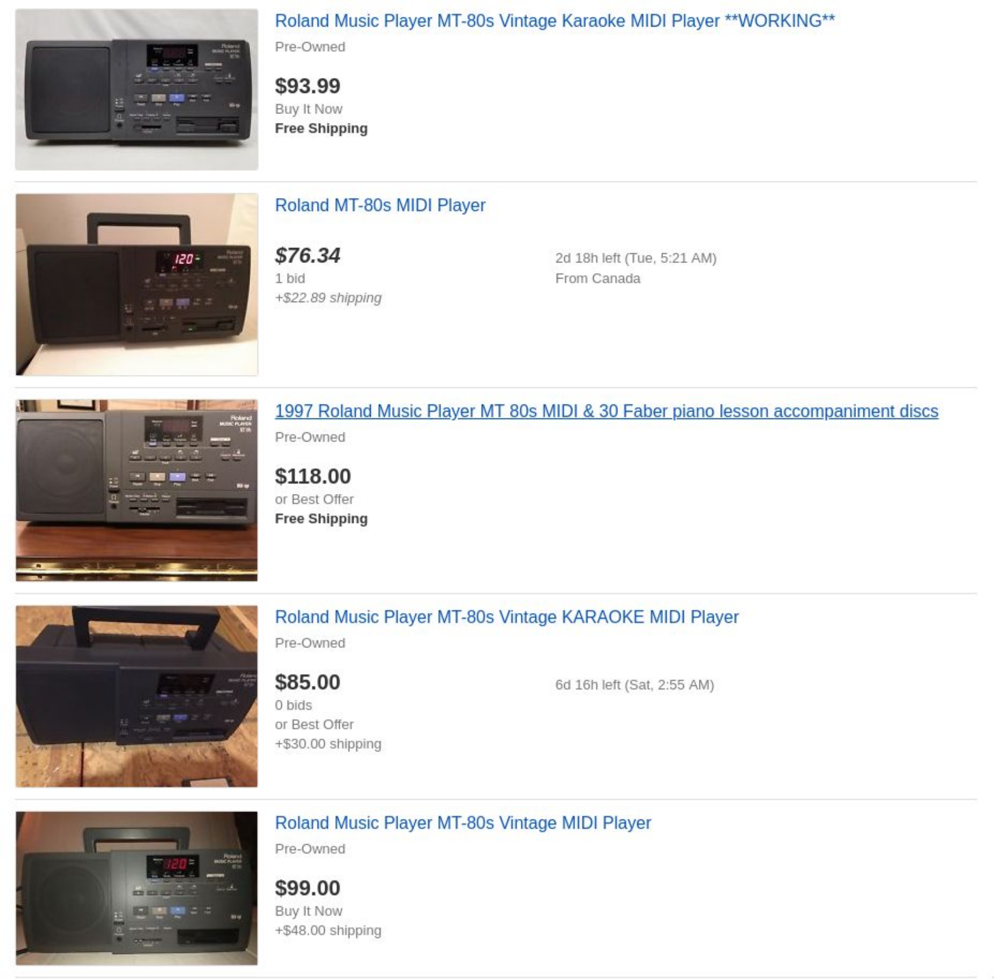
```
func ParseEvent(f io.Reader) map[string]string {
    event := make(map[string]string, 0)
    buf := bufio.NewScanner(f)
    for buf.Scan() {
        fields := strings.SplitN(buf.Text(), "=", 2)
        if len(fields) < 2 {
            return event
        }
        event[fields[0]] = fields[1]
    }
    return event
}
```

Track 3:
Hardware

Back in 90s

- Roland made a "music tutor" that played back MIDI from 3.5" floppies

In 2019



Roland Music Player MT-80s Vintage Karaoke MIDI Player **WORKING**

Pre-Owned

$93.99

Buy It Now

Free Shipping

Roland MT-80s MIDI Player

$76.34

1 bid

+$22.89 shipping

2d 18h left (Tue, 5:21 AM)

From Canada

1997 Roland Music Player MT 80s MIDI & 30 Faber piano lesson accompaniment discs

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$118.00

or Best Offer

Free Shipping

Roland Music Player MT-80s Vintage KARAOKE MIDI Player

Pre-Owned

$85.00

0 bids

or Best Offer

+$30.00 shipping

6d 16h left (Sat, 2:55 AM)

Roland Music Player MT-80s Vintage MIDI Player

Pre-Owned

$99.00

Buy It Now

+$48.00 shipping

Building My Own

- Raspberry Pi 3+
- MIDI synthesizer attached to serial port
- Floppy drive over USB
- Player written in Go

Why Go?

JBD says (https://github.com/rakyll/go-hardware):

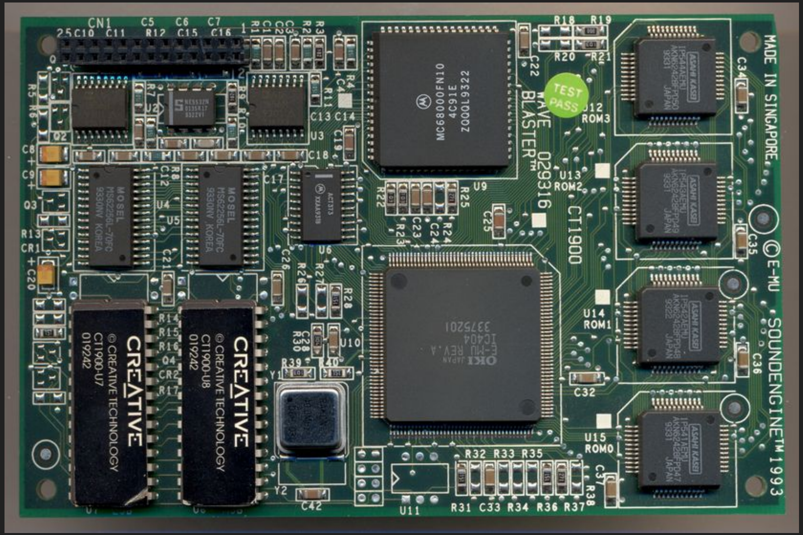
- "Out-of-the-box cross compilation"
- "Built-in concurrency primitives"
- "Go programs compile to static binaries"
- "Go is efficient, fast and has low memory footprint"
- "Code reuse"

I says:

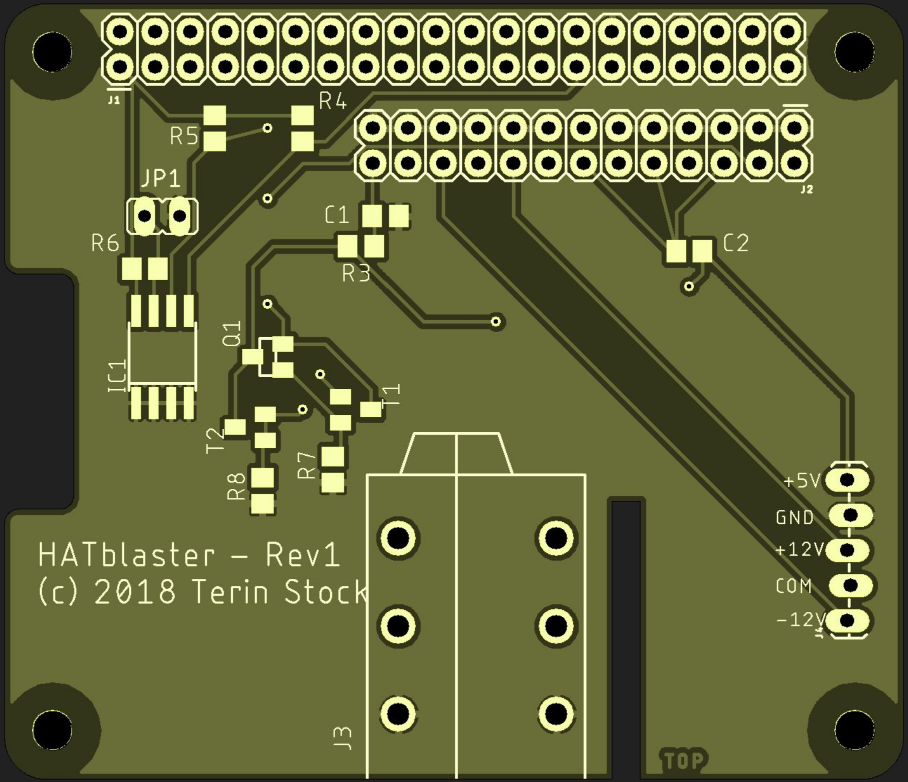
- "Not C"
- "Out of the box toolchain"

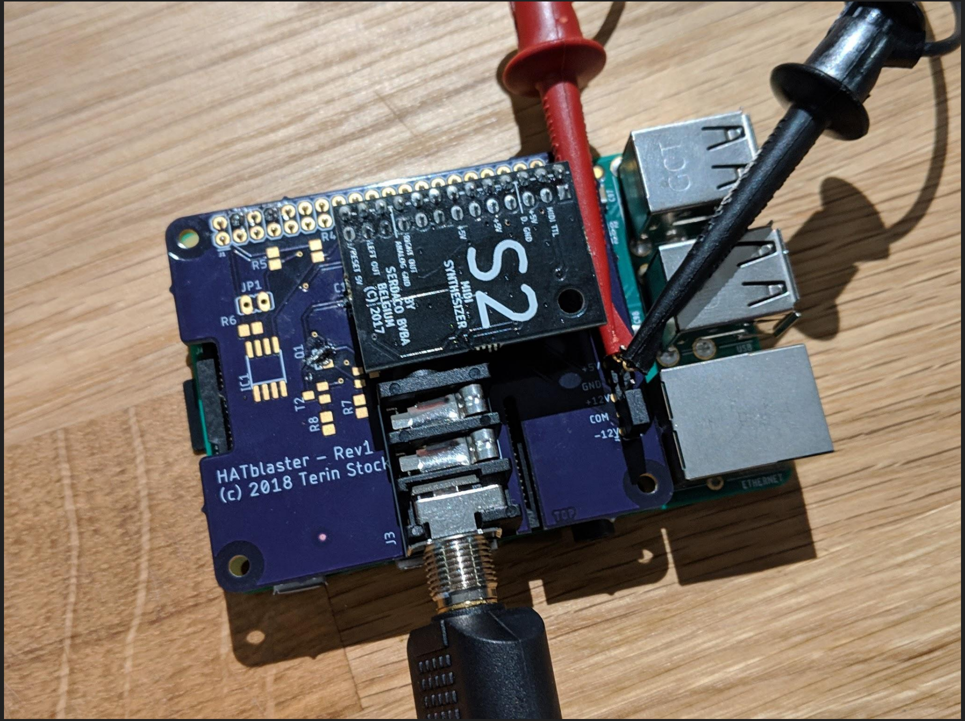
MIDI Synthesizer

- Many classic MIDI synths are available in WaveBlaster-compatible daughterboards
  - Creative WaveBlaster
  - Yamaha DB60XG
  - Roland SCB-55
  - Korg Ai20
- A few modern synthesizers are available
  - Serdaco Dreamblaster X2
  - Serdaco Dreamblaster S2



WaveBlaster Hat




HATblaster – Rev1
(c) 2018 Terin Stock
S2
MIDI SYNTHESIZER
BY SERDACO BVBA BELGIUM
(C) 2017
/RESET 5V
LEFT OUT
RIGHT OUT
ANALOG GND
+5V
+5V
D. GND
+5V
MIDI TTL
R4
R5
JP1
R6
C1
Q1
IC1
T2
R7
R8
J3
+5V
GND
+12V
COM
-12V
GCT
USB
ETHERNET

Track 4:
Demo

Demo gods got me :(

Track 5:
Conclusion

We're Hiring

SAY NO! TO SLOW LOAD TIMES!
CLOUDFLARE
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SECURE ALL SITES!
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CLOUDFLARE
THE GLOBAL CLOUD NETWORK
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PERFORMANCE AND SECURITY UNITED
JOIN 10 MILLION DOMAINS ON CLOUDFLARE
DATA BREACHES GOTTA GO!
A BETTER INTERNET IS HERE
KEEP HACKER HANDS OFF YOUR NETWORK!

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  - Main developer on gokrazy
- Chiel Kersten (http://members.home.nl/c.kersten/)
  - Large catalog of WaveBlaster-compatible daughterboards

Thanks!

- Blog: https://terinstock.com
- Code: https://git.terinstock.com
- Twitter: @terinjokes