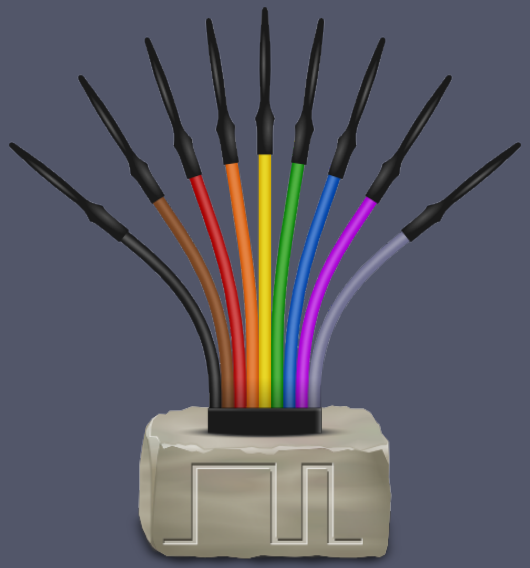

Sigrok: Using Logic to Debug Logic

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sigrok Overview

- Provides a simple Open Source solution for mostly proprietary and some Open Source Hardware digital logic devices
- Common framework which includes output format, device metadata, and H/W interfacing

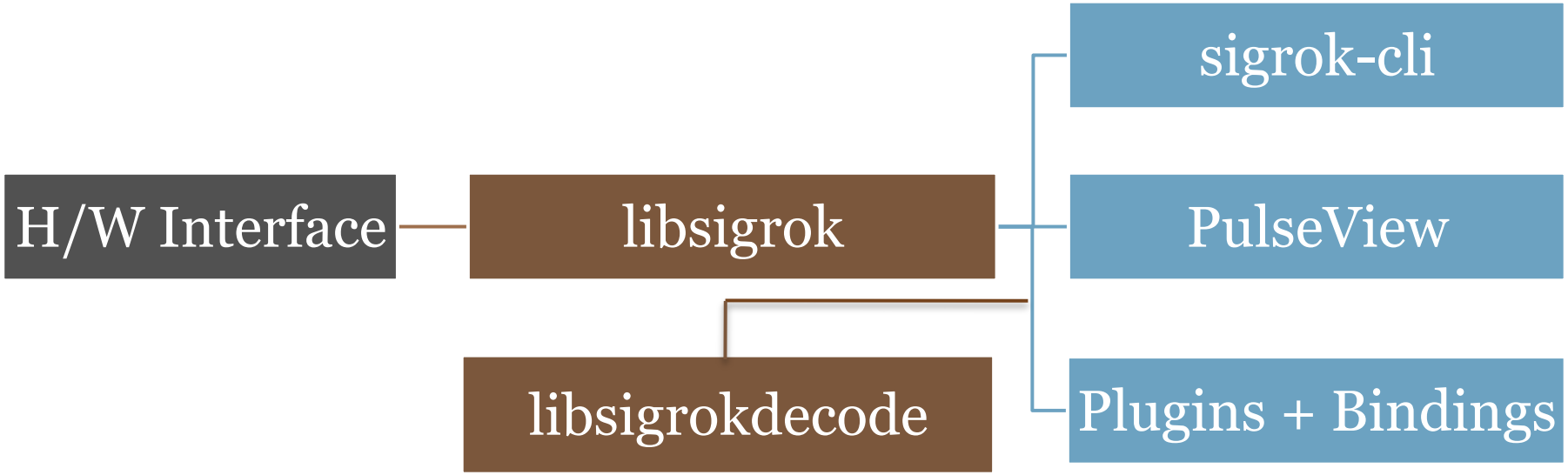
sigrok Project

- Blanket project with various libraries, backends, protocol decoders, third-party firmware, and graphical frontends
- Aims to make a common framework for a various of logic analyzers, oscilloscopes, and other analog/digital debugging devices

Meet The Family

- libsigrok – Heart and brains behind the device communication, functionality, and control
- libsigrokdecode – Python3 interfacing lib in C + protocol decoders
- sigrok-cli – Command line backend for sigrok
- sigrok-util – Various useful scripts + utilities
- sigrok-dumps – Collections of various captures
- fx2lafw – OSS Firmware for Cypress FX2 LAs
- PulseView – sigrok QT GUI frontend

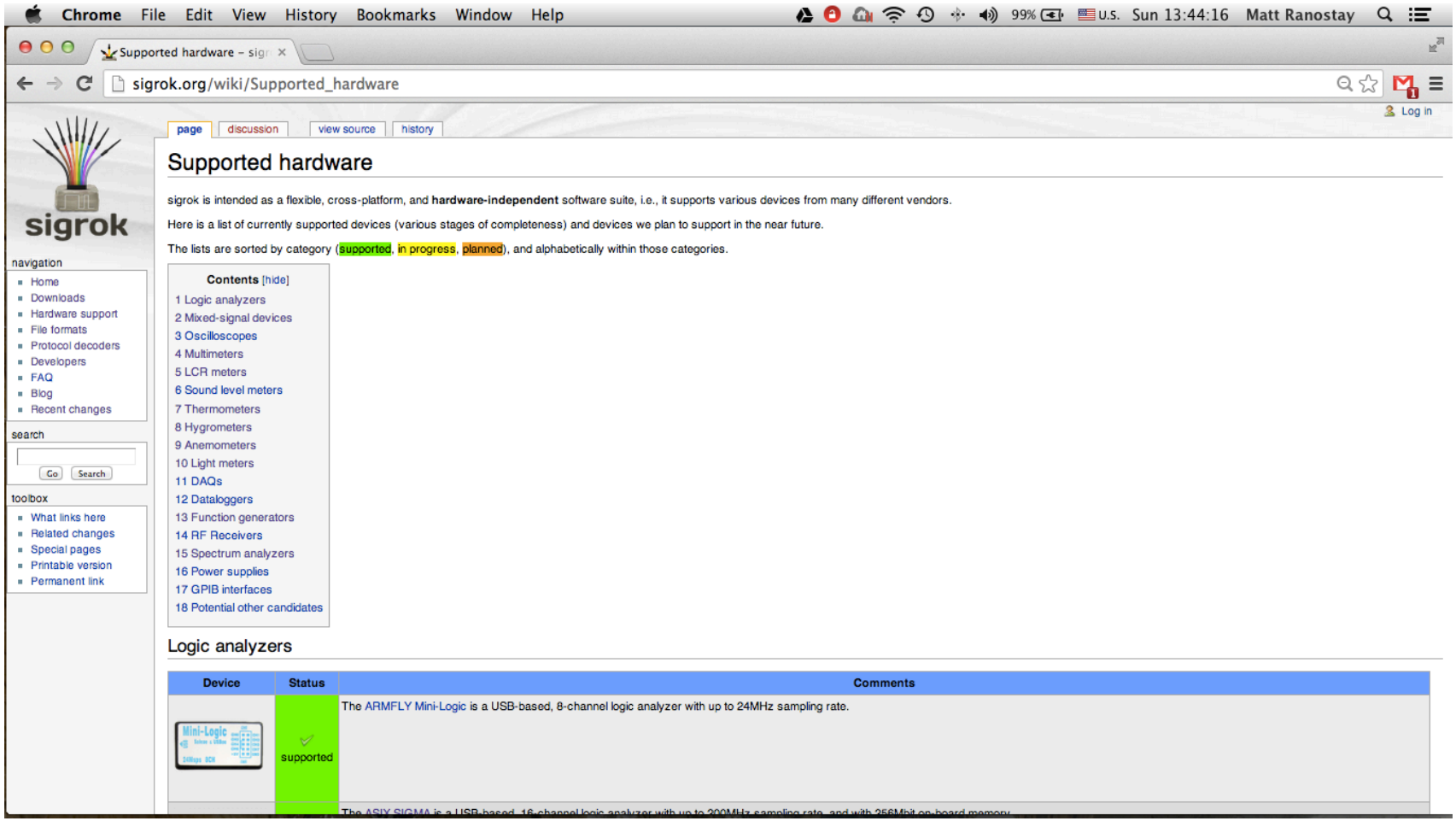
sigrok Components



Examples of Supported Devices

- Logic Analyzers
  - Open Logic Sniffer
  - Saleae Logic/Logic 16
- Oscilloscope
  - Rigol DS1052E
- Mixed-Mode Devices
- Digital Multimeter
- Analog devices like thermometers, hygrometers, light meters, etc
- Full support list available on sigrok wiki

Supported Devices



sigrok output format

- Device agnostic and interchangeable
- Simple hexdump to process
- Compressed with zip algorithm
  - Due to most samples being repeats it isn't rare to see compression rates of 100x
- Traces can be broken into chunks (e.g. logic-* files in archive)
- Common metadata that is useful for clients and protocol decoding

sigrok Metadata

[global]
sigrok version = 0.2.12
[device 1]
driver = saleae-logic16
capturefile = logic-1
unitsize = 1
total probes = 16
samplerate = 500 kHz
probe1 = RX
probe2 = TX
probe3 = PPS

sigrok Probe Data

```
$ unzip nmea_gps_500khz_500k_samples.sr
$ hexdump logic-1
0000000 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03
*
0002e50 03 03 03 03 03 03 03 02 02 02 02 02 02 02 02 02
0002e60 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02
*
0002ef0 02 02 02 03 03 03 03 03 03 03 03 03 03 03 03 03
0002f00 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03
*
0002f20 03 03 03 03 03 03 03 02 02 02 02 02 02 02 02 02
0002f30 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02
*
0002f80 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 03
0002f90 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03
...
```

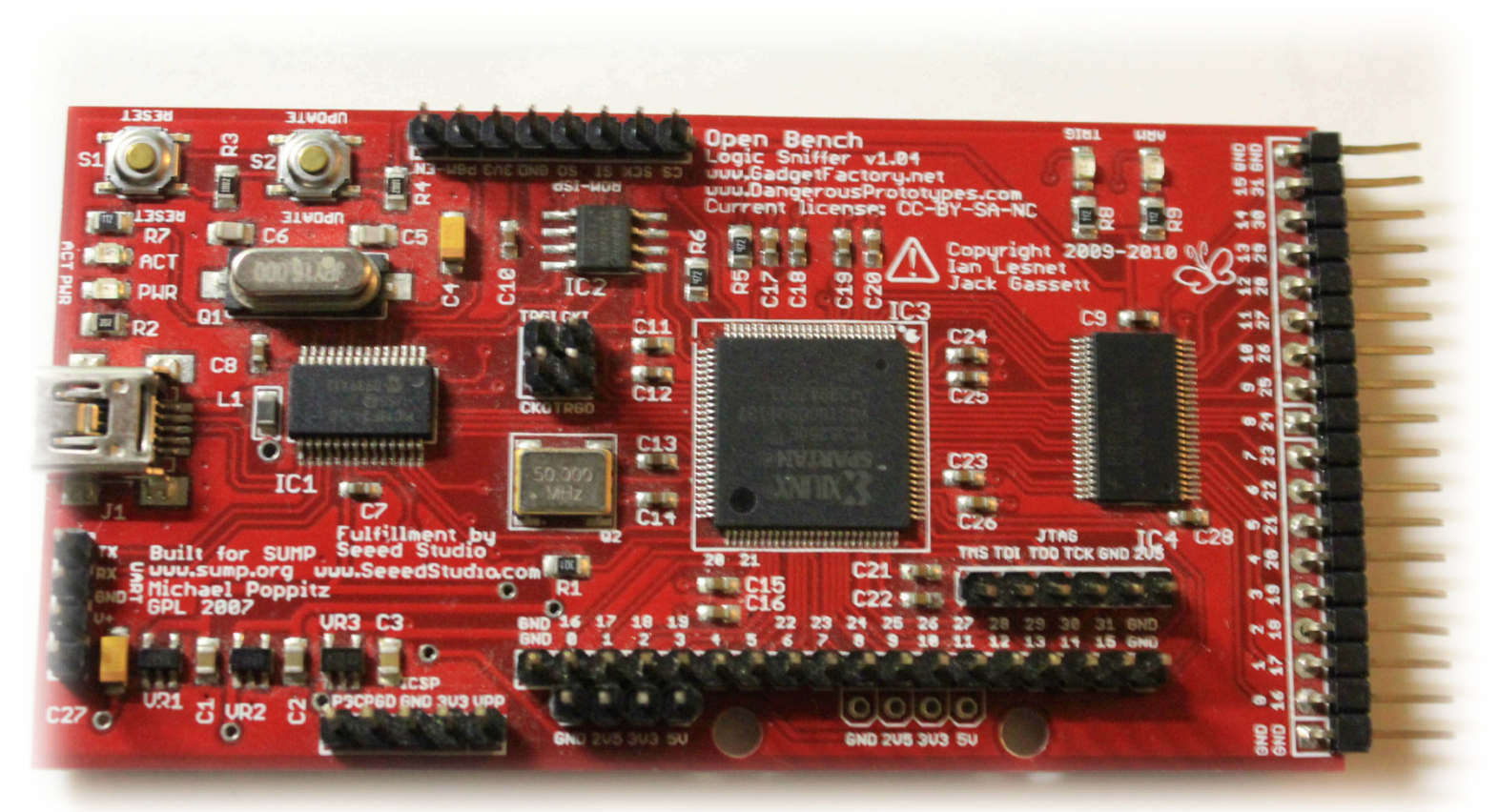
Other sigrok supported outputs

- VCD / Value Change Dump
- Analog (for DMMs and DSOs)
- Comma Separated Values
- GnuPlot
- Various vendor/device specific formats
  - OLS – Open Logic Sniffer Java client output
  - ChronoVu LA8

Logic Analyzer Visited

- Open Logic Sniffer (50$ USD)
  - Pros
    - Inexpensive + completely OSHW + OSS
    - 100mhz sampling
    - 200mhz DDR mode
    - H/W triggers
    - Run Length Encoding
    - External Clock + Trigger In/Out
  - Cons
    - Dead project + questionable design decisions
    - Only 24Kb sample buffer
    - High speed traces are useless without using RLE

Open Logic Sniffer



Logic Analyzers Visited Continued

- Saleae Logic (150$ USD, although clones can be found much cheaper)
  - Cypress FX2 microcontroller which has open source third-party firmware (sigrok-firmware-fx2lafw)
- Saleae Logic 16 ($299 USD)
  - Pros
    - Sampling three channels @ 100 mhz, 6 @ 50mhz, 9 @ 32mhz, 16 @ 16mhz with recent firmware
  - Cons
    - S/W only triggers
    - No H/W buffer, data is piped over the USB 2.0 interface, and random timeouts can end trace early

Saleae Logic 16

Protocol Decoders

- Magically translates the dump into user grokable output
- All the common bus protocols supported
  - I2C/SMBUS
  - SPI
  - CAN
  - 1Wire
  - UART
  - USB
- Stackable protocol decoders
  - Saves the user from hand decoding underlying protocol layers, e.g., SPI -> AVR ISP, i2c -> Wii Nunchuck, 1wire-link -> 1wire-network

Protocol Decoder Continued

- Protocol decoding can be done in CLI or GUI
- Examples of useful CLI based protocol decoding
  - UART -> UART dump (NMEA 0183 output)
    - sigrok-cli -i nmea_0183.sr –P uart:baudrate=9600,uart_dump
  - i2c -> i2c-filter -> RTC DS1307
    - sigrok-cli –i rtc_ds1307.sr -P i2c:scl=0:sda=1,i2cfilter:address=0x68,ds1307
- Examples of useful GUI base protocol decoding
  - Multiple signals and protocols side by side
    - NMEA 0183 + Pulse Per Second
    - I2c GPIO Expander + GPIO status
    - SPI UART + UART data

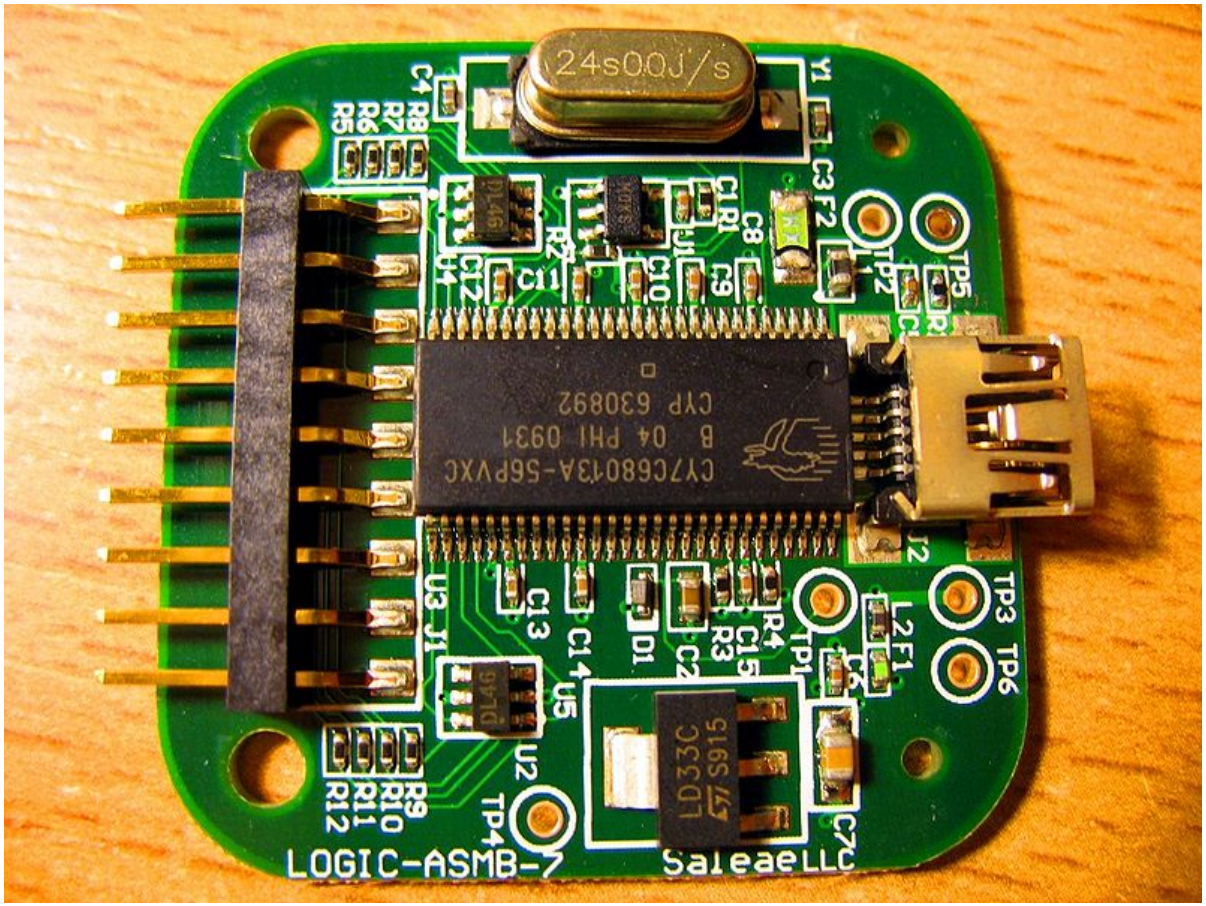
Creating Protocol Decoders

- sigrok protocol dumps are required for any new protocol decoder submissions
  - Split up commands into multiple dumps
  - Document everything that will likely be useful
- Decoders are written in Python so it's very easy to prototype and implement
- Annotations both in output and protocol forms
  - Allows stacking of PDs, for example i2c output into ds1307
- Decoder design should be scalable and extensible
- Most decoders are and should be written as state machines

FX2 Chipset Devices

- Open Source Source firmware available from sigrok project
  - Microcontroller over USB every device initialization
- Various low end logic analyzers (aka clones of Logic) use this
- Good enough for 90% of your debugging
  - I2C + SPI + 1Wire busses
  - Once you require over the 24mhz sampling clock that probably requires going a little higher-end

Logic Breakdown + Cypress FX2 chip



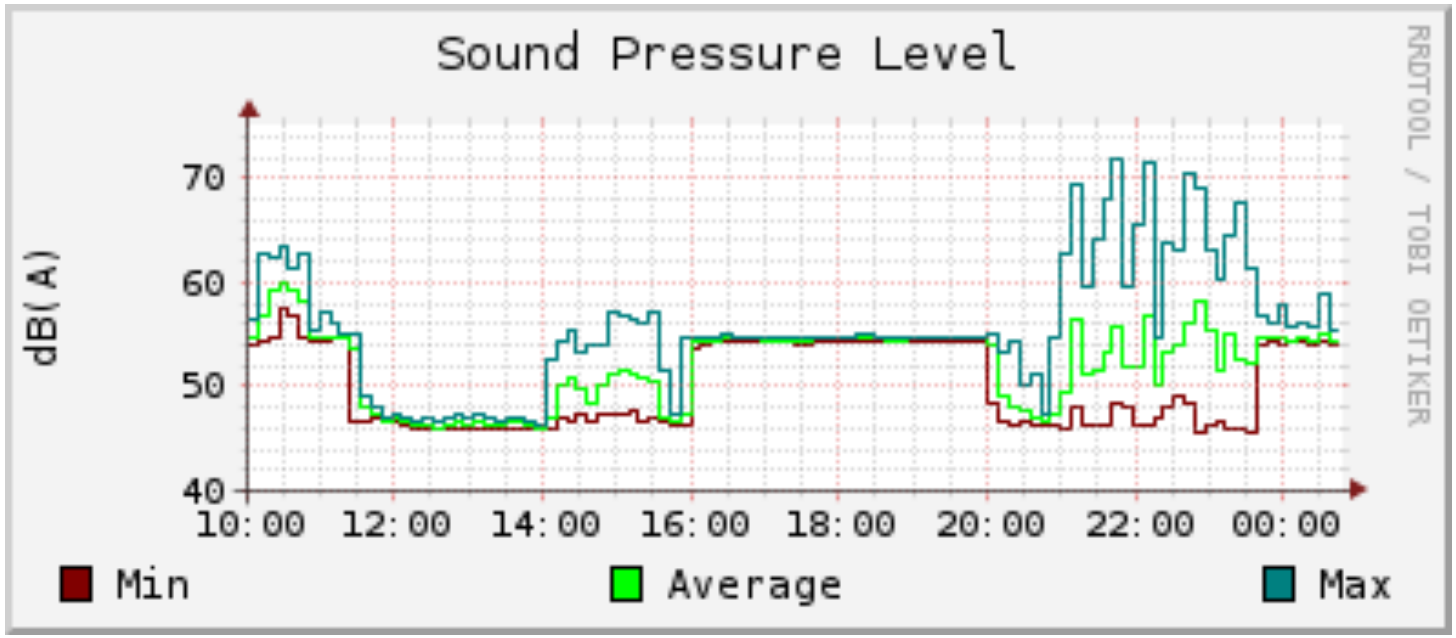
In Progress/Planned Features

- Advanced Triggers
  - Serial triggers
  - Multi stage triggers
- Software Triggers
  - Saleae Logic/Logic 16 (plus others) for example supports only SW triggers
  - Allow more dynamic options without hacking Verilog…
- Analog to Digital channel conversion
- Multiple devices per capture
- PulseView having Protocol Decoder + Analog support)

sigrok Bindings + Plugins

- Python bindings
- SWIG bindings
- collectd plugin
  - Allows reporting of sigrok supported analog devices in an industry standard RRDtool format
  - Simply allows a circular database of data and creating useful graphs from them
  - Use cases would be using a sound level meter or in server room, or monitoring Carbon Monoxide levels near a furnace

collectd Example



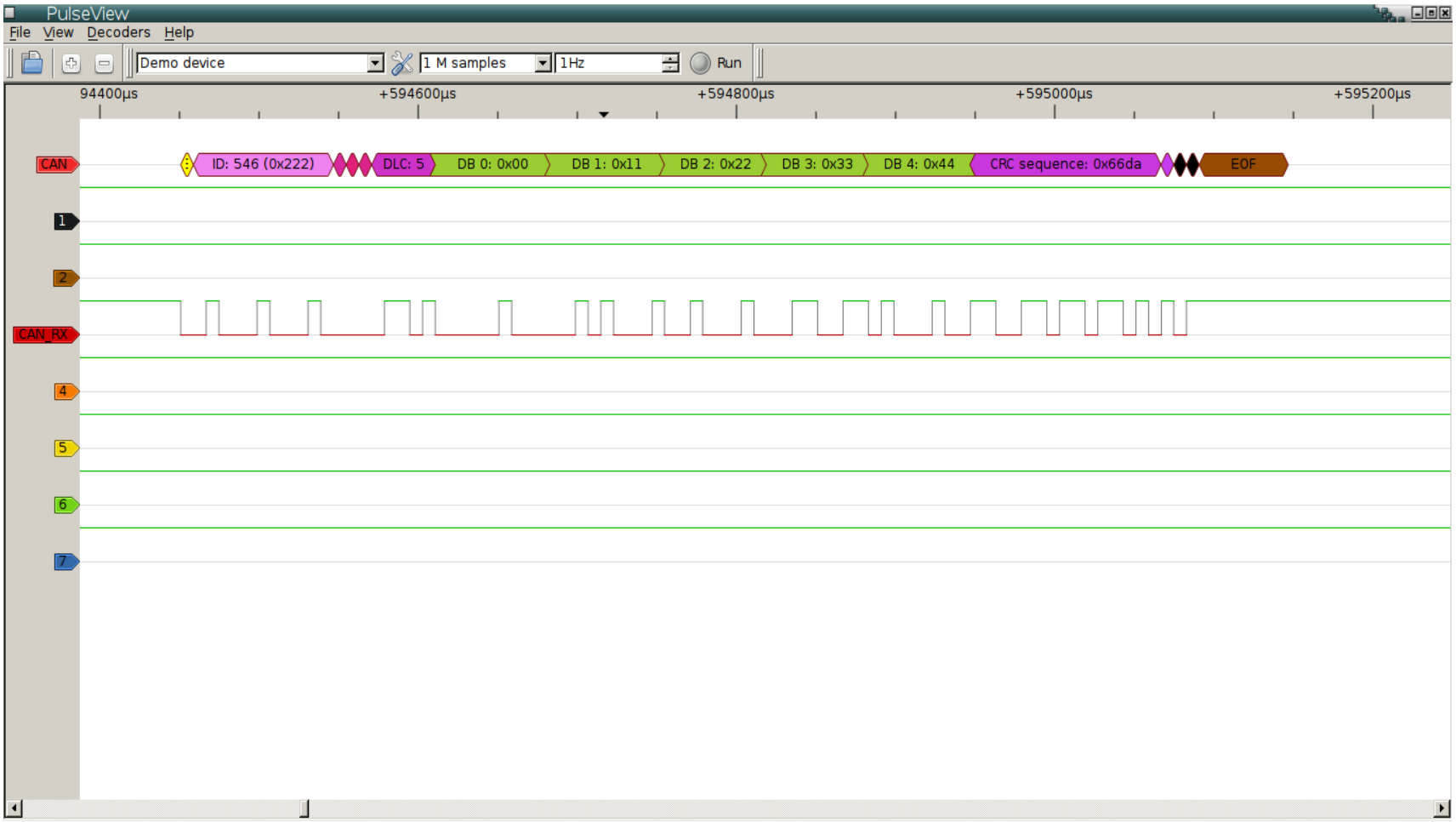
collectd Example Continued

```
LoadPlugin “sigrok”
<Plugin “sigrok”>
   LogLevel 3
  <Device “Sound level”>
        Driver “cem-dt-885x”
        conn “/dev/ttyUSB1”
        MinimumInterval 1
  </Device>
</Plugin>
```

PulseView

- First true graphic frontend for sigrok
  - Previous attempts really buggy
- Allows running of traces and visual displaying of samples + protocol decoders
- Was a vital missing piece for the sigrok project

PulseView continued



Everything is Broken - Logic Analyzer

- Continuous samples are a myth…
  - USB 3.0 may hold the hope for the future
- Run Length Encoding is a good solution but there are hold-ups
- Triggers type are important
- External clocking can be very useful
- Chaining with external triggers outs/ins

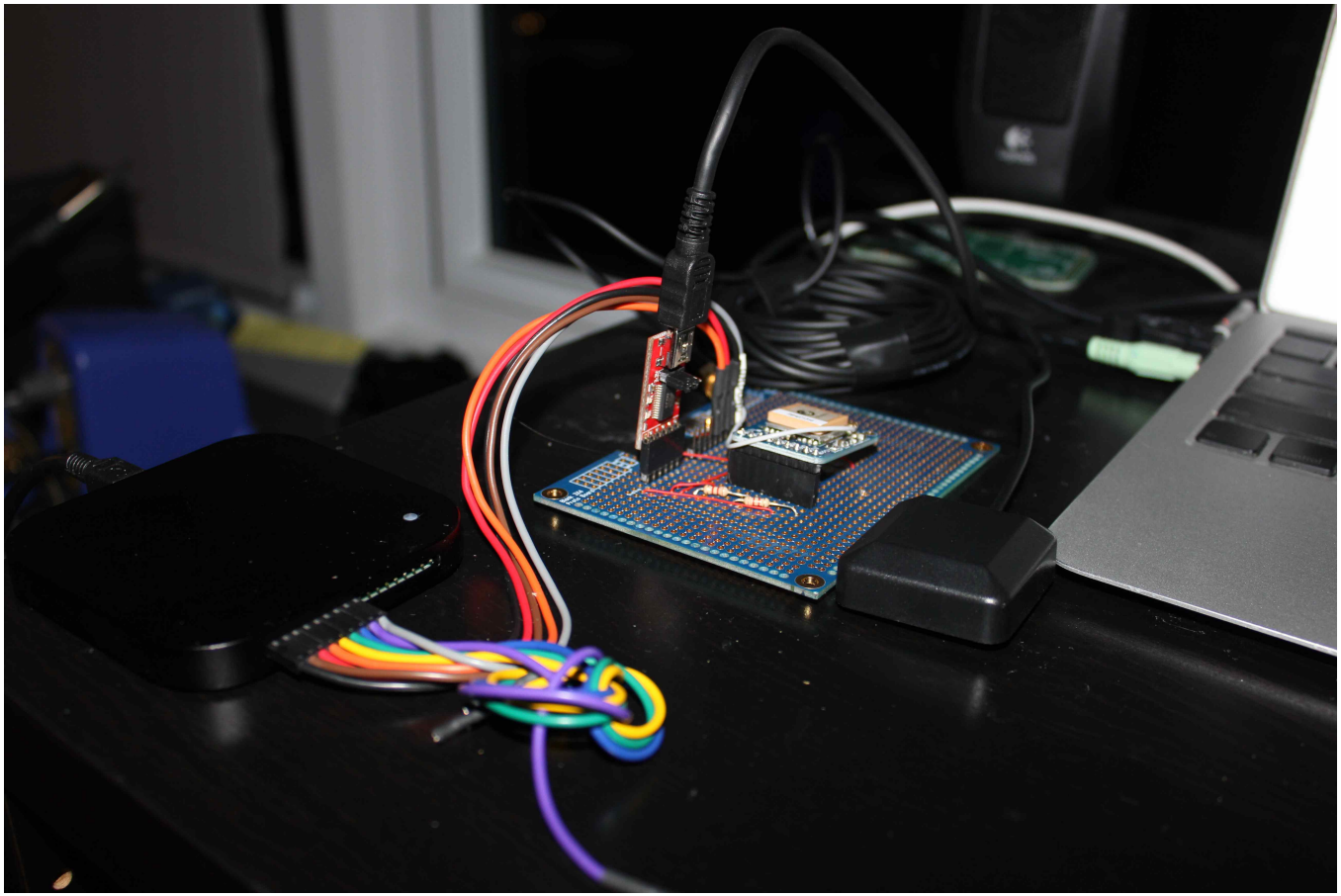
Weird Solutions

- Run Length Encoding hacks
  - Use more groups than you need
  - Waiting forever is possible…
- Simple microcontrollers/microprocessors as logic analyzers
  - Cypress FX2 + AM335x PRU
- Multiple devices chained or multiple channel groups for different logic levels

Demo

- sigrok-cli
  - Example of when using text based output is more useful than the UI interface
  - Protocol Decoding
  - Tracing the ASCII way
- PulseView
  - Live capture + display of samples
    - Saleae Logic 16 tracing of NMEA 0183 output from GTPA013 GPS module

Demo Setup



Community

- Send us your protocol dumps in sigrok format
  - No protocol too odd or ancient for submission
  - Examples of ones we'd want are DMX512, MIDI, NMEA, CAN bus devices, and various I2C devices
  - First step to a protocol decoder… even if you aren't the one writing it
- Smoke out bugs and report any that are found
- Contribute to the wiki, post device breakdowns, protocol disassembly, etc
- Free hardware samples to support? (couldn't hurt to ask ☺)
- As always patches are welcome!

Questions?

- What are the features the users need most?
- Where is sigrok advanced or lacking compared to other OSS projects or even closed-source ones?

References + Links

- http://sigrok.org
- http://sigrok.org/wiki/Supported_hardware
- http://en.wikipedia.org/wiki/Sigrok
- http://dangerousprototypes.com/docs/Open_Bench_Logic_Sniffer
- http://www.saleae.com/logic16
- http://www.adafruit.com/products/1096
- http://collectd.org/
- http://www.rigolna.com/products/digital-oscilloscopes/ds1000e/ds1052e/

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