Wireless Fidelity with bwfm(4)

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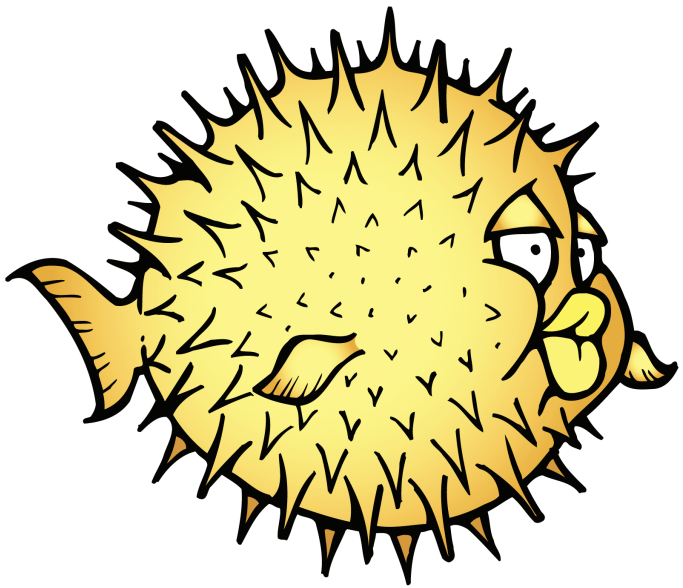
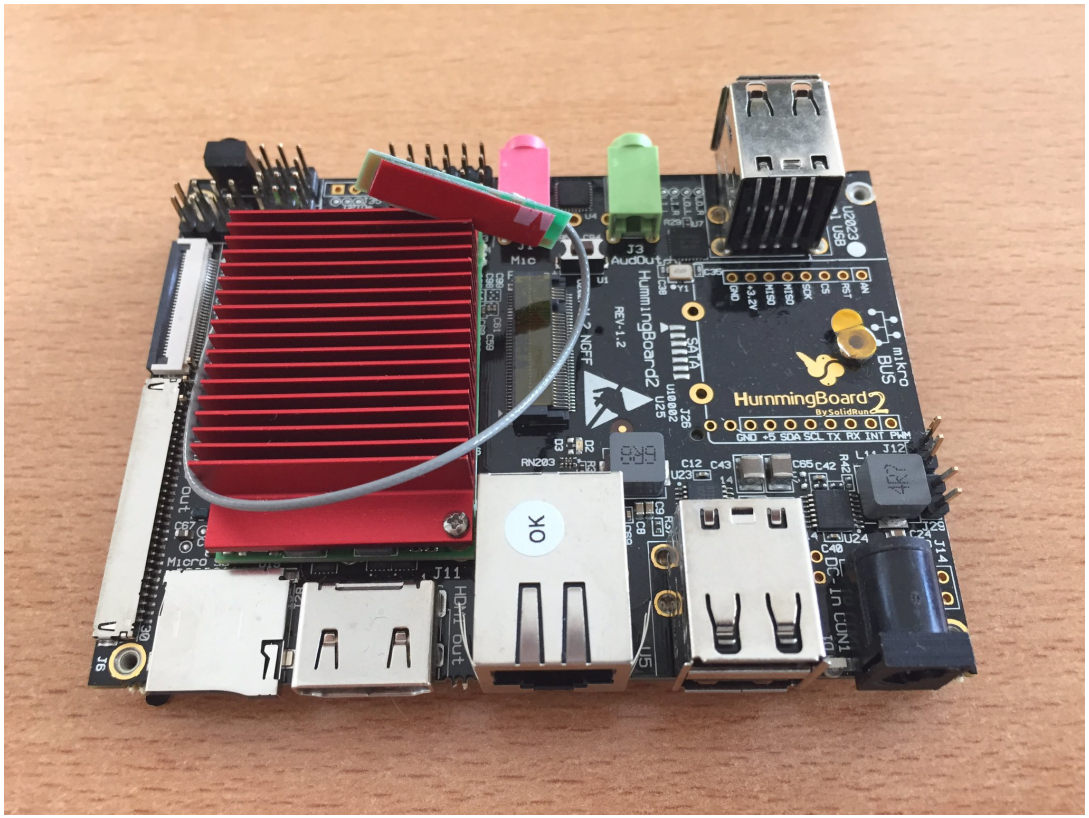
Who am I?

- OpenBSD developer
- ARM64-subtree maintainer
- LLVM-subtree updater
- SBC hoarder

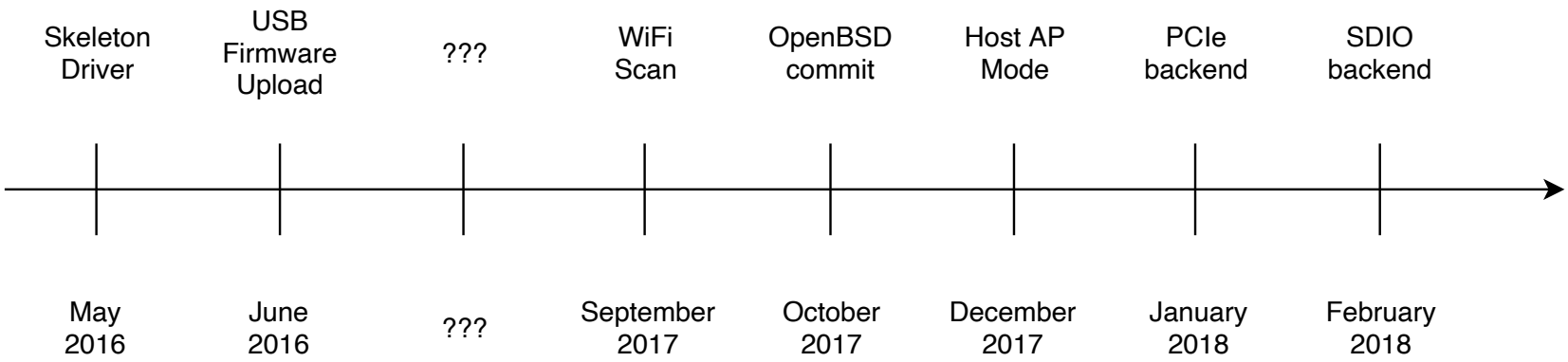


Collection of devices

- Cubox-i
- Macbook
- Raspberry Pi 3
- Z83 Mini-PC



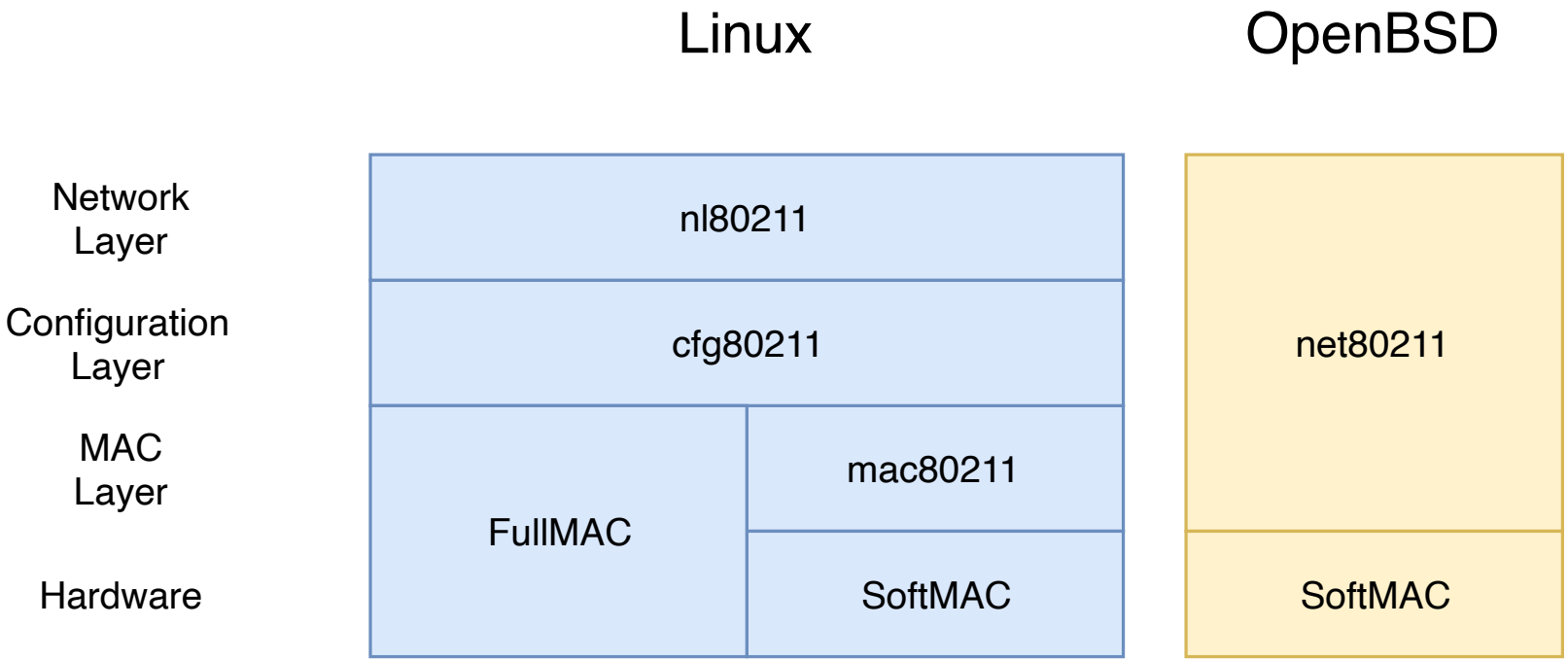
Milestones


Skeleton Driver
USB Firmware Upload
???
WiFi Scan
OpenBSD commit
Host AP Mode
PCIe backend
SDIO backend
May 2016
June 2016
???
September 2017
October 2017
December 2017
January 2018
February 2018

Study

1. Find documentation
   - Search the web for datasheets (by chip name)
   - git grep in various OS (chip name, vendor/product ID)
   - Neither code nor datasheet? Quit now.
   - Alternative: reverse engineering
2. Study code and/or documentation to grasp concepts
   - Attention: license concerns!
3. Realize it's going to be a long project

Full vs Soft (simplified)



brcm80211

ISC-licensed brcm80211 drivers (Linux):

brcmfmac	brcmsmac
FullMAC	SoftMAC
35 496 LoC	75 177 LoC

brcmsmac/phy/phy_n.c: 28 624 Lines Of Magic

Jobs

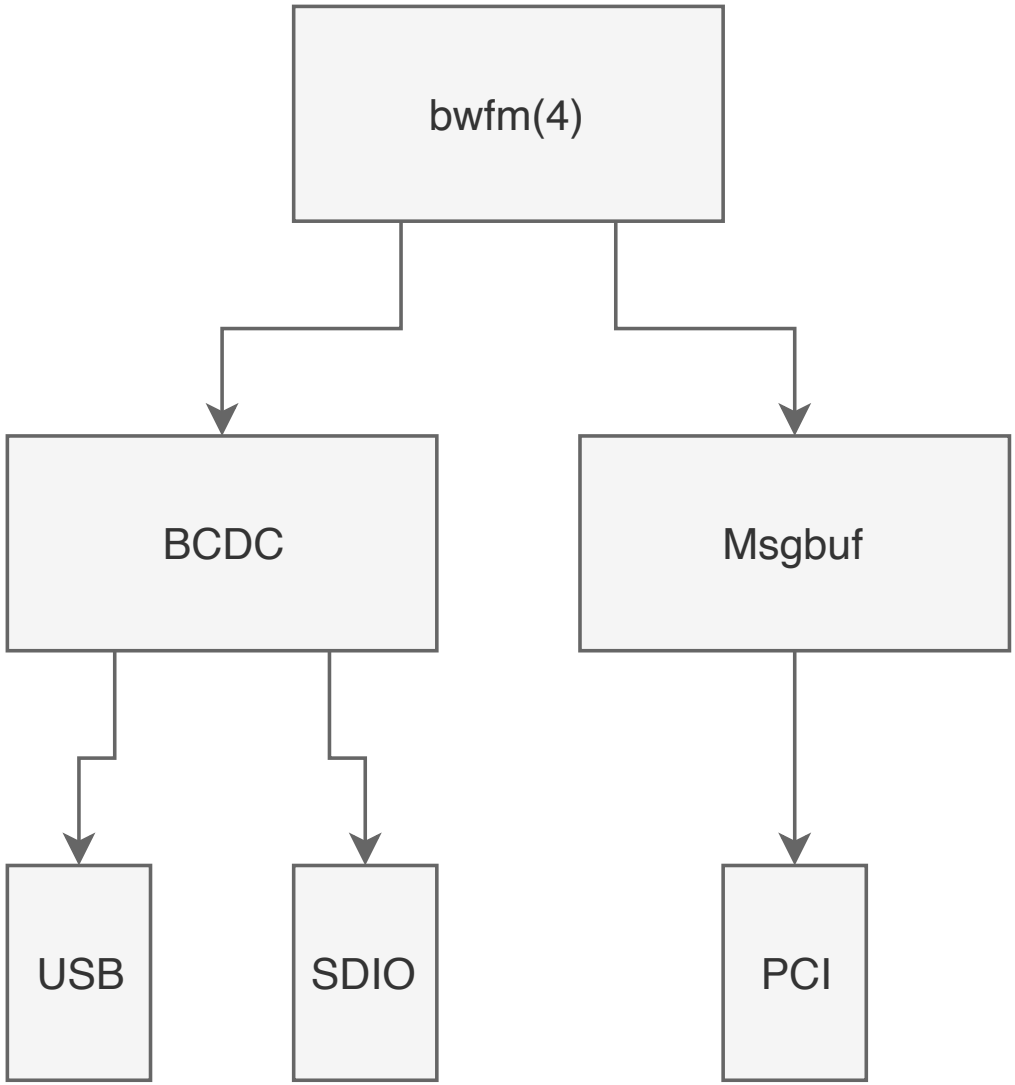
What do we **not** have to do?

- No beacons
- No frequency changes
- No MCS handling

What do we have to do?

- Initiate scan
- Configure SSID
- Configure keys
- Handle events
- Handle network packets

Skeleton



Dongle

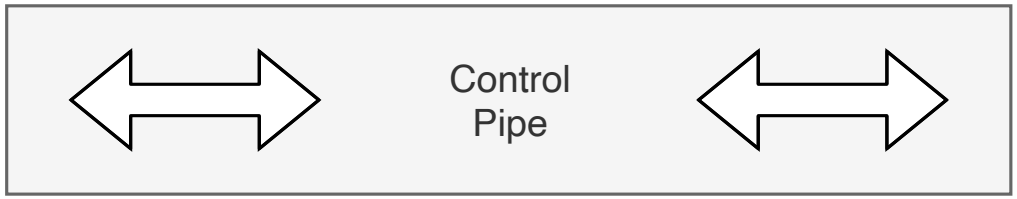
1. Started with SDIO
   - But realized testing kernels will take too long
   - Unsure if SDIO layer actually worked
2. Bought a USB device
3. Started with the lower layers
4. Added PCIe/SDIO backend later

Write code that compiles

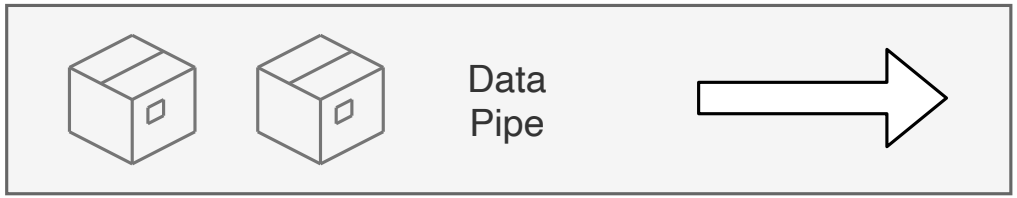
1. Skeleton-driver
2. Initialize bus access
3. Try to figure out whether the device is alive
   - read chip id
   - read MAC address
   - receive an interrupt

USB

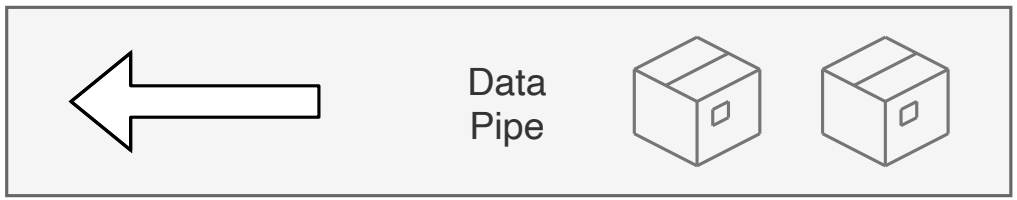
Configuration



Data



Data+Events



Configuration

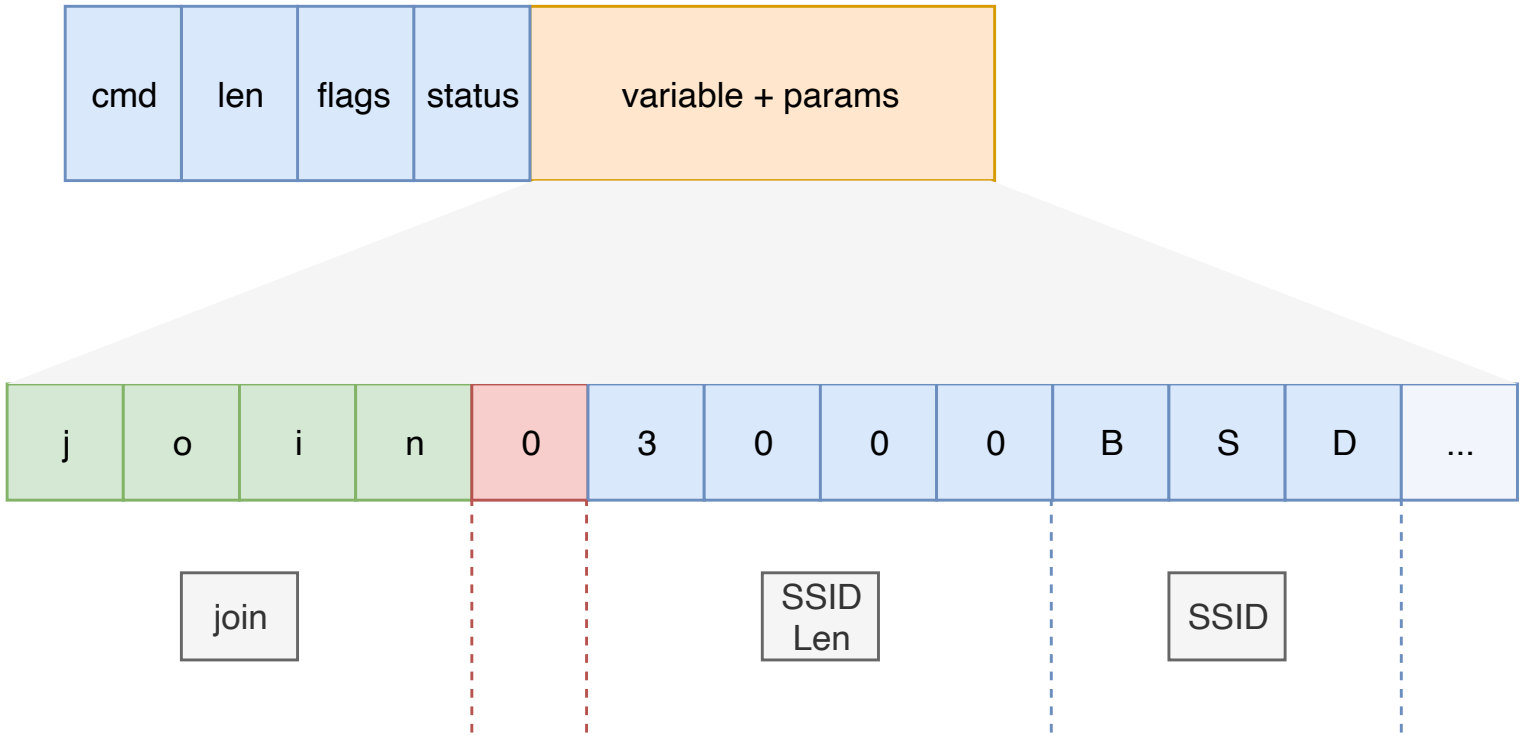
Initiate Scan:

```
struct bwfm_escan_params *params;
[...]
bwfm_fwvar_var_set_data(sc, "escan",
    params, params_size);
```

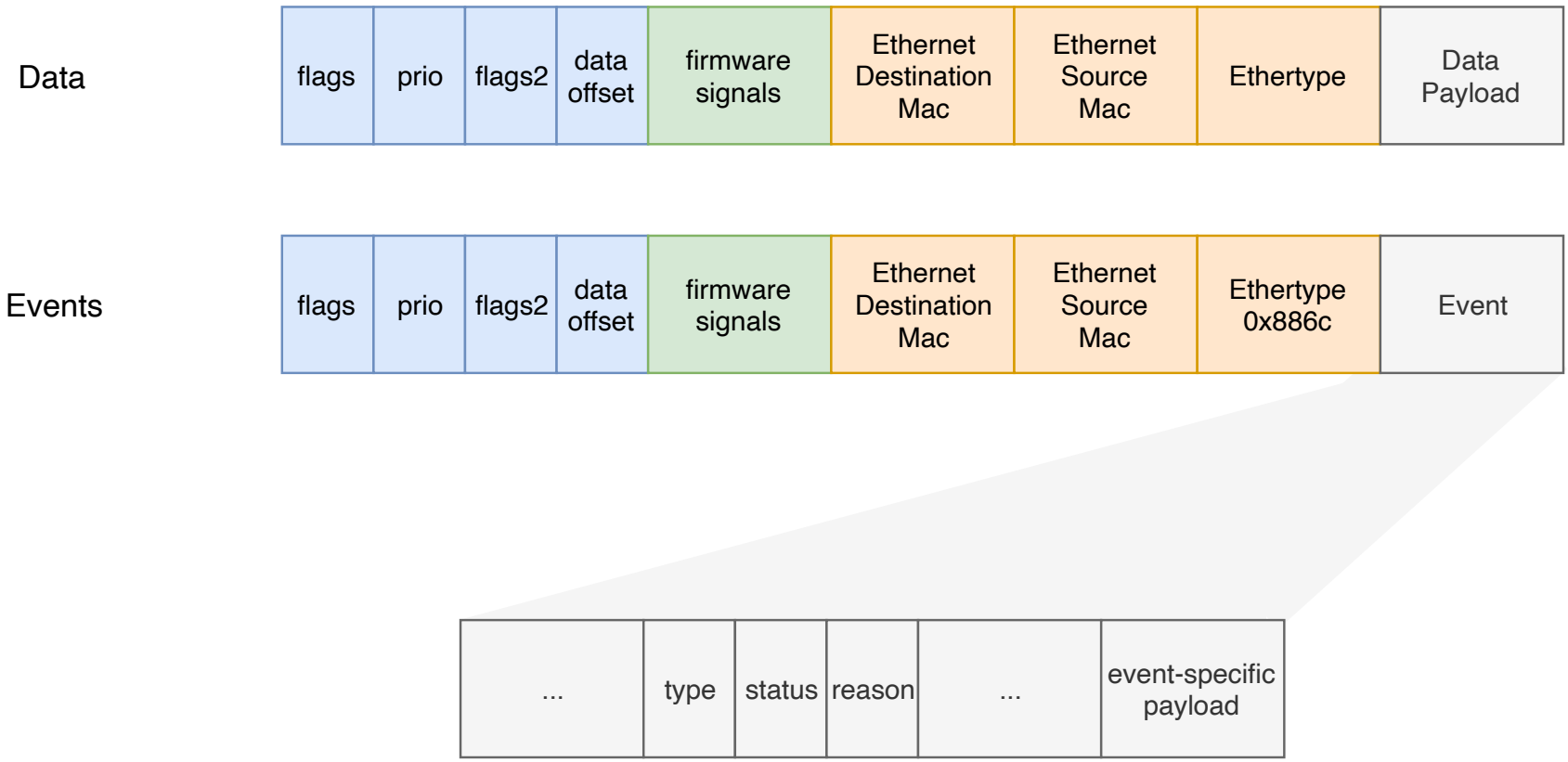
Connect to SSID:

```
struct bwfm_ext_join_params *params;
[...]
bwfm_fwvar_var_set_data(sc, "join",
    params, sizeof(*params));
```

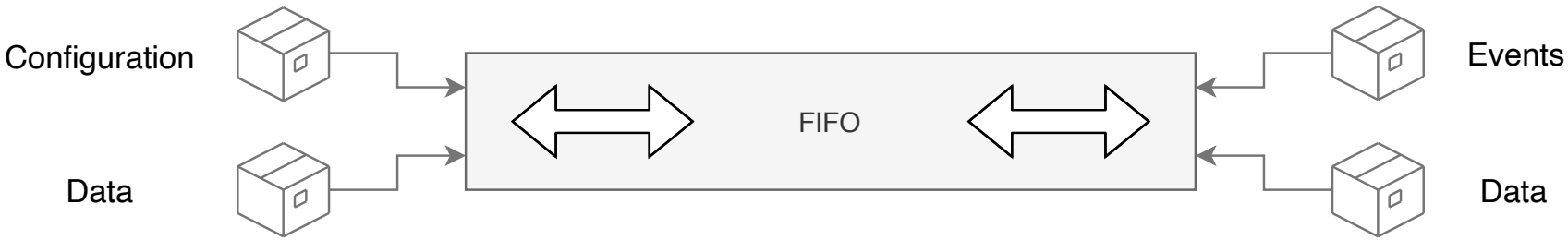
Connect to SSID



BCDC Packets

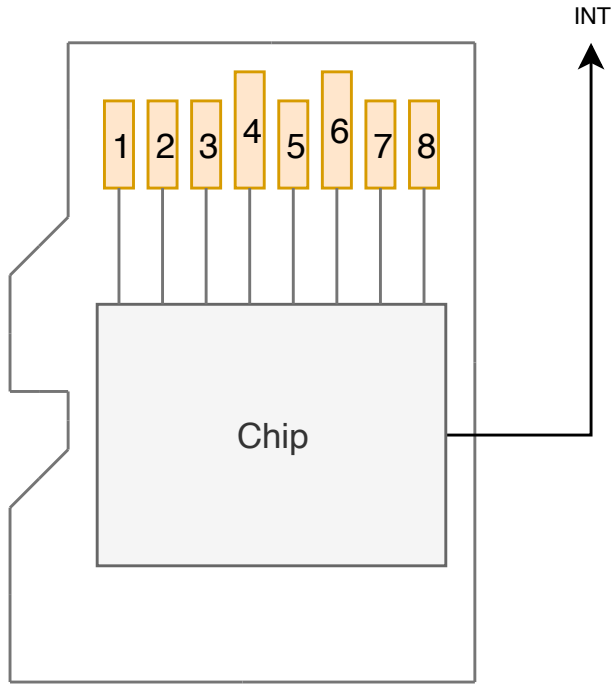


SDIO



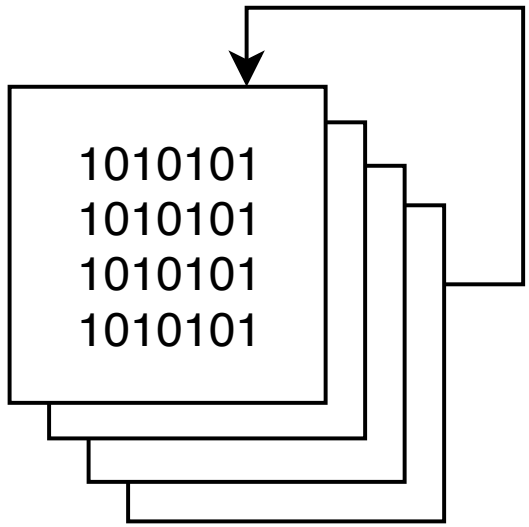
SDIO Interrupt

- Shared pin: DAT[1]/IRQ
- Sampled as IRQ during *Interrupt Period*
- Some host controllers have troubles
- Workaround: externally routed GPIO



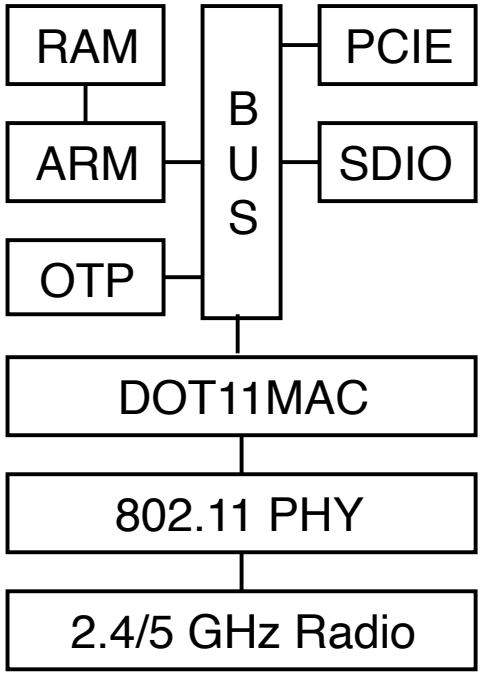
PCIe

- Packet-based
- Multiple Ringbuffers
  - TX Control Ring
  - TX RX-Post Ring
  - (Control, TX, RX) Complete Rings
  - *n* Flowrings



Package

- Read/write access to backplane
- Write Firmware & NVRAM
- Turn on/off ARM core
- Read dmesg



dmesg

```
hndarm_armr addr: 0x18002000, cr4_idx: 0
000000.001 RTE (SDIO-MSG_BUF) 7.35.180.119 (r594535) on BCM4350 r8
           @ 37.4/240.8/240.8MHz
000000.001 allocating a max of 255 rxcplid buffers
000000.002 pciemsgbuf0: Broadcom PCIE MSGBUF driver
000000.003 reclaim section 0: Returned 59036 bytes to the heap
000000.131 enable 1: q0 frmcnt 0, wrdcnt 0, q1 frmcnt 0, wrdcnt 0
000000.131 enable 1: q0 frmcnt 0, wrdcnt 0, q1 frmcnt 0, wrdcnt 0
000000.175 wl0: Broadcom BCM4350 802.11 Wireless Controller 7.35.180.119
           (r594535)
000000.175 TCAM: 256 used: 255 exceed:0
000000.176 reclaim section 1: Returned 147512 bytes to the heap
000005.375 wl0: wlc_enable_probe_req: state down, deferring setting of
           host flags
000005.413 wlc_bmac_switch_macfreq: 4350 need fix for 37.4Mhz
000005.421 wl0: wlc_enable_probe_req: state down, deferring setting of
           host flags
000005.421 enable 1: q0 frmcnt 0, wrdcnt 0, q1 frmcnt 0, wrdcnt 0
```

Firmware Features

4356a2-roml/**pcie**-ag-msgbuf-splitrx-**p2p**-pno-aoe-pktfilter-keepalive-**sr**-**mchan**-pktctx-proptxstatus-ampduhostreorder-lpc-pwropt-txbf-wl11u-mfp-tdls-amsdutx-sarctrl-proxd-hs20sta-rcc-wepso-ndoe-linkstat-gscan-hchk-logtrace-roamexp-rmon

Version: 7.35.101.6 (r702795)
CRC: 4f3f65c5
Date: Sun 2017-06-04 16:51:38 PDT
Ucode Ver: 963.316
FWID: 01-5e8eb735

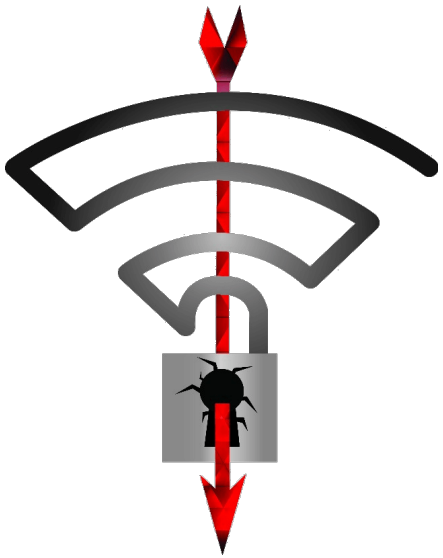
Tricky bits

- Flow-control
- Asynchronous control messages
- Asynchronous creation of flowrings
- net80211 Integration

Firmware

- Remote Control Message Injection (CVE-2016-0801):
  Updated firmware in November 2017
- KRACK (October 2017):
  Updated firmware in June 2018

(based on linux-firmware.git)



KRACK

```
/*
 * The firmware supplicant can handle the WPA
 * handshake for us, but we honestly want to
 * do this ourselves, so disable the firmware
 * supplicant and let our stack handle it.
 */
bwfm_fwvar_var_set_int(sc, "sup_wpa", 0);
```

NVRAM

Purpose:

- Provides configuration for the specific package
- Sets up antenna configuration, max dB, etc.

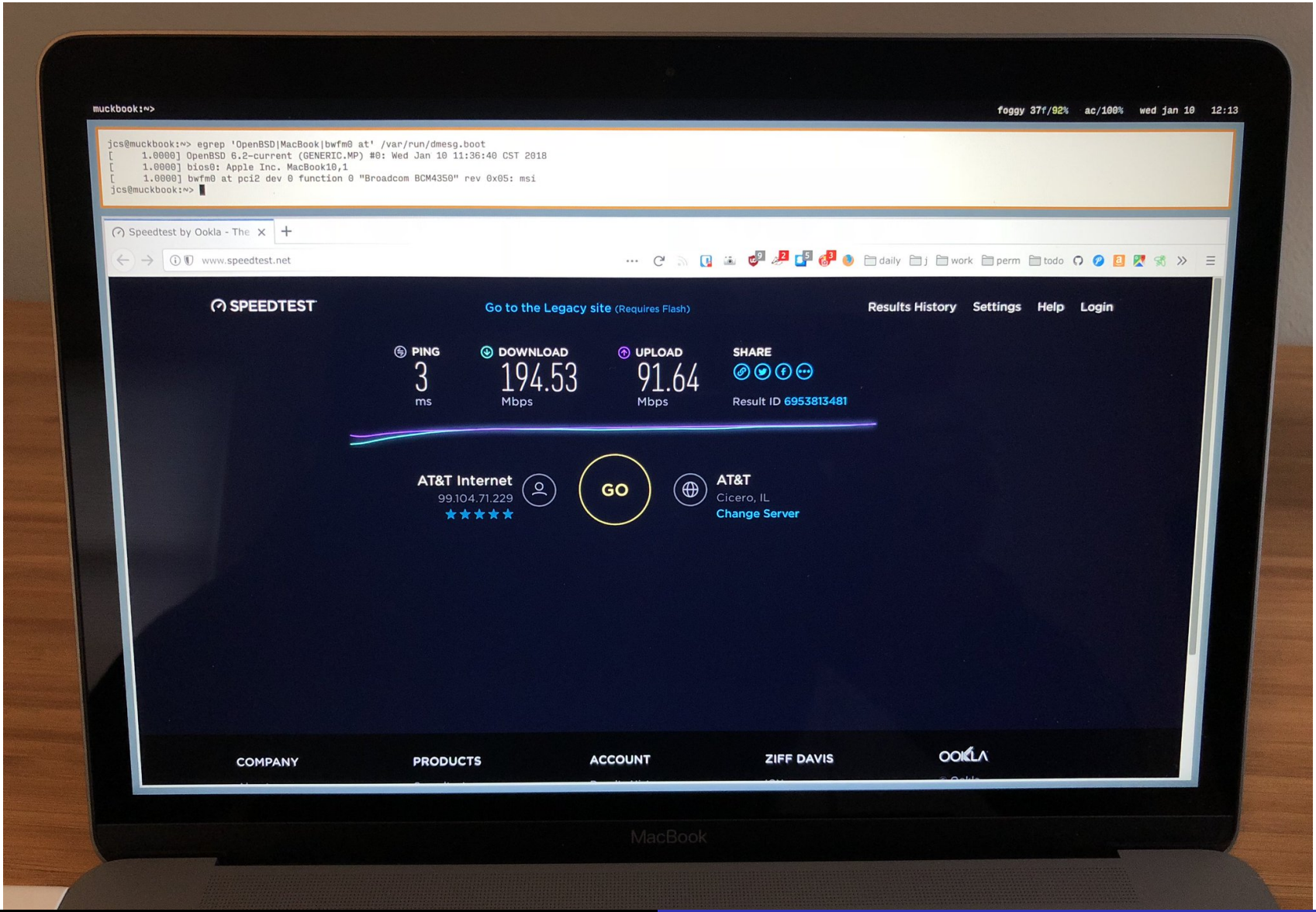
Needed on:

- PCIe (sometimes)
- SDIO (always)
- USB (not yet?)

Provided by:

- Hardware designer (in their git repo)
- EFI BIOS (in an EFI variable)

Current Status



Current Status

- Works as client
- Properly fast 802.11ac (Wi-Fi 5)
- Implemented on recent Macbooks
- Implemented on raspberry Pis
- Available as *official raspberry Pi USB Dongle* (while supplies last)
- Works as access point often enough

Future

- Better AP support
- Multi-AP support
- Suspend/Resume
- Firmware Signals
- Support for more devices

Questions?