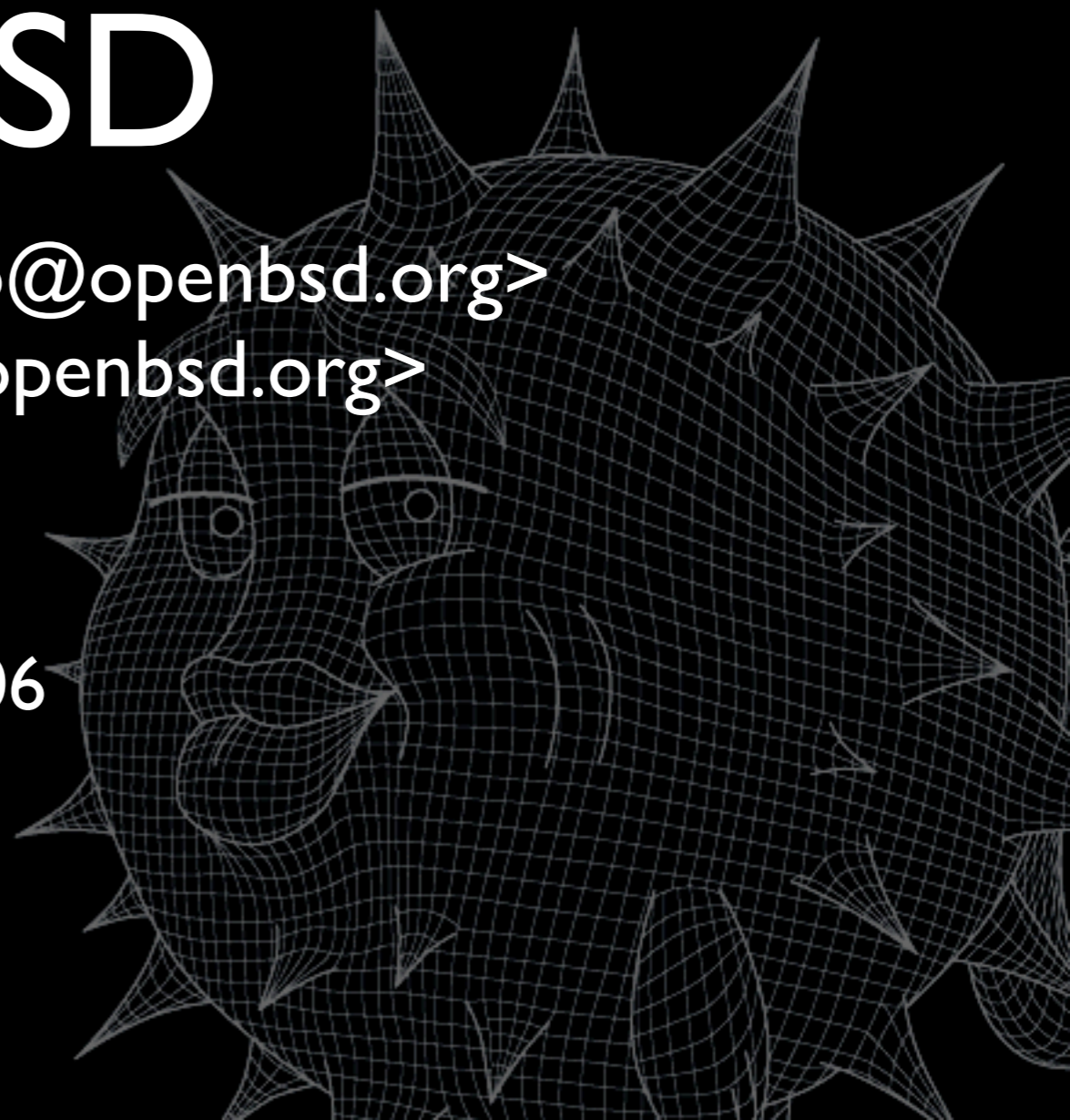


# bio and sensors in OpenBSD

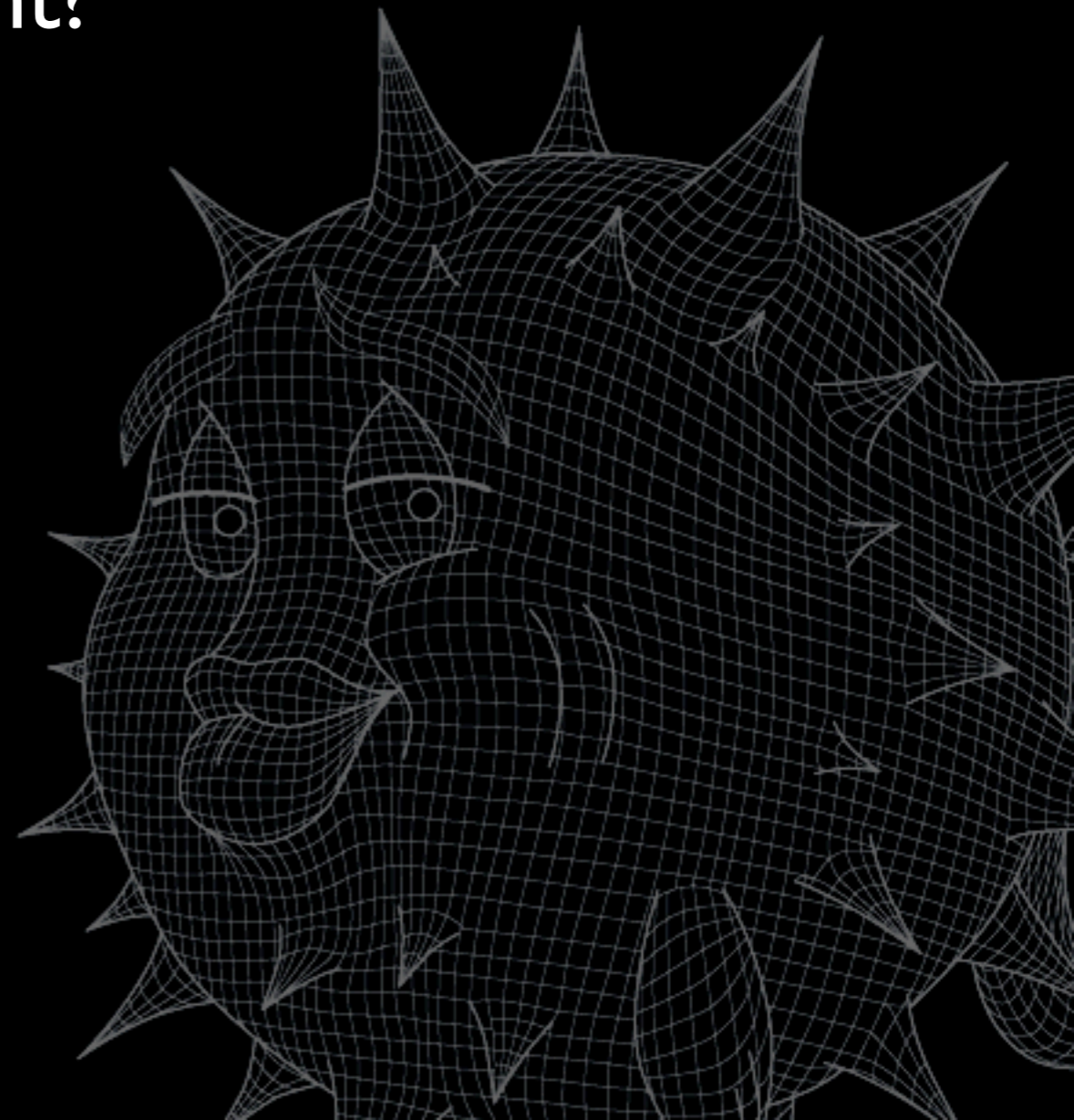
Marco Peereboom <marco@openbsd.org>  
David Gwynne <dlg@openbsd.org>

BSDCan 2006



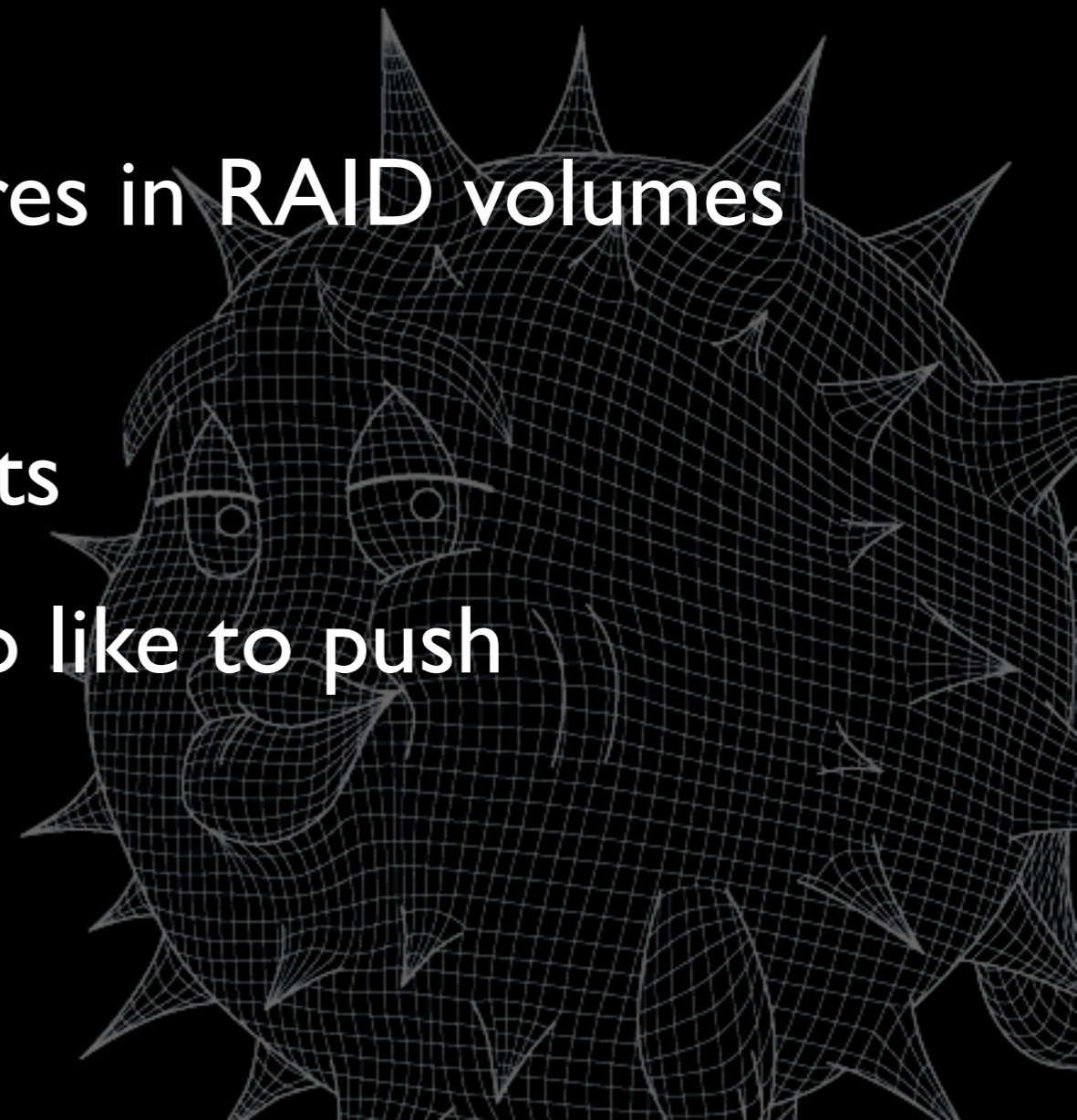
# introduction

- what is RAID management?
- what are sensors?
- why do we care?
- what's the problem?
- what's the solution?



# what is RAID management?

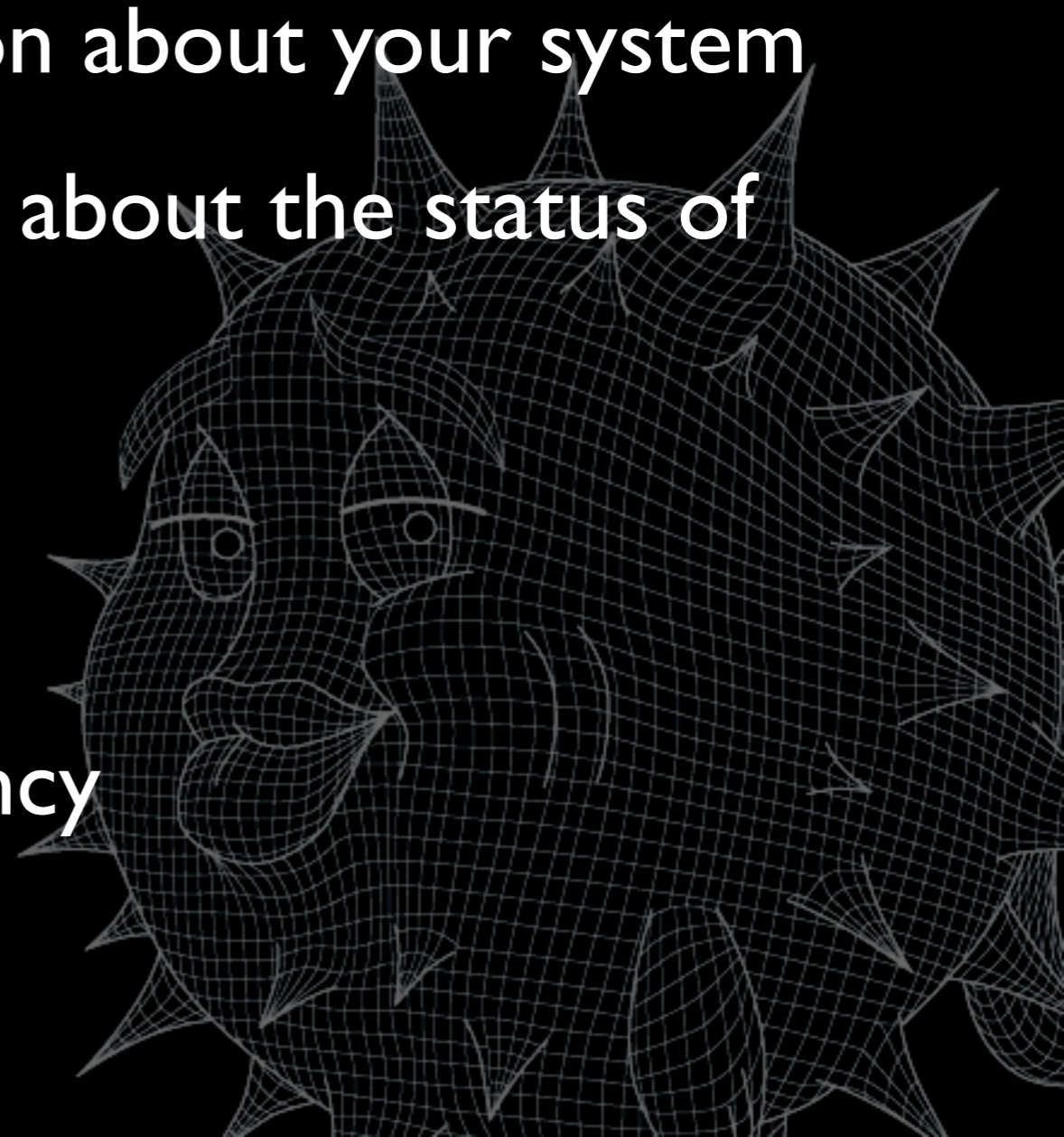
- the ability to see the configuration of RAID sets
- the ability to detect failures in RAID volumes and components
- the ability to fix RAID sets
- extra bits for people who like to push buttons



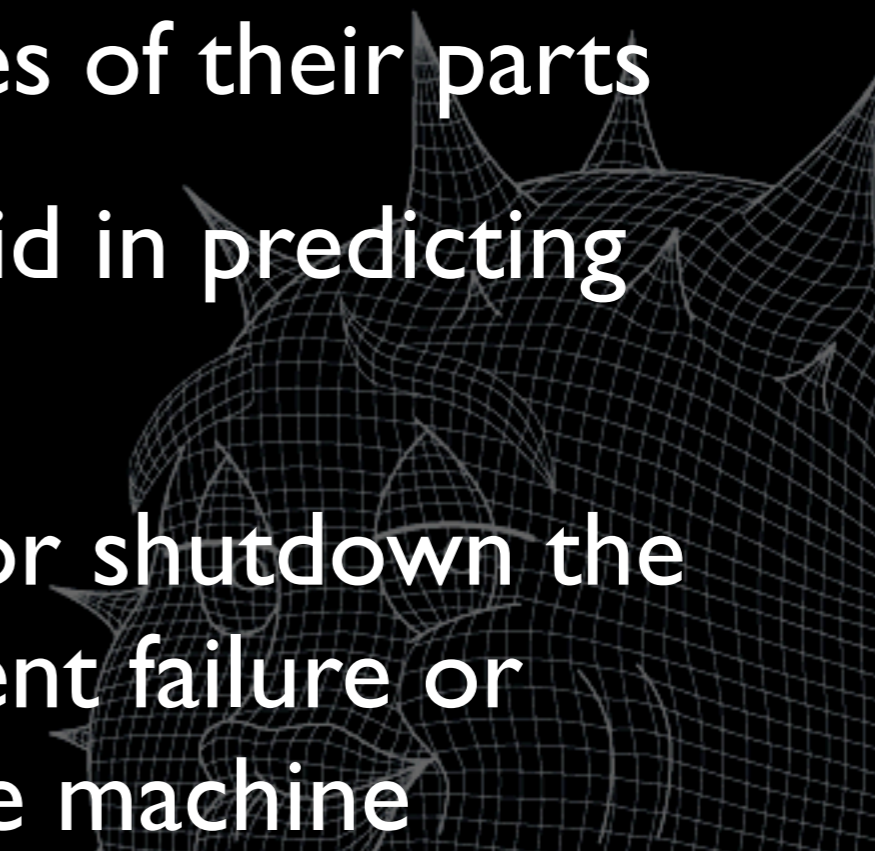


# what are sensors?

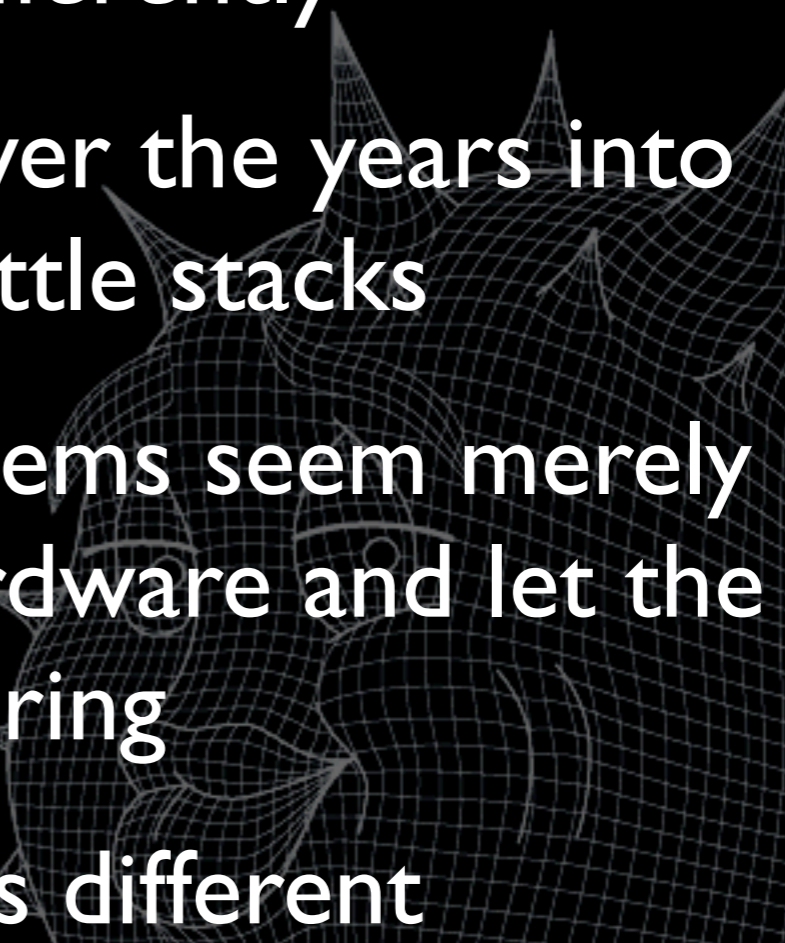
- sensors are anything that provides environmental information about your system
- anything that can tell you about the status of your components, eg:
  - cpu temp and voltage
  - ambient temp
  - power supply redundancy



# why do we care?

- computers are now built with redundancy so they can withstand failures of their parts
  - environmental readings aid in predicting potential future failures
  - we can replace the part or shutdown the machine before component failure or permanent damage to the machine
- 

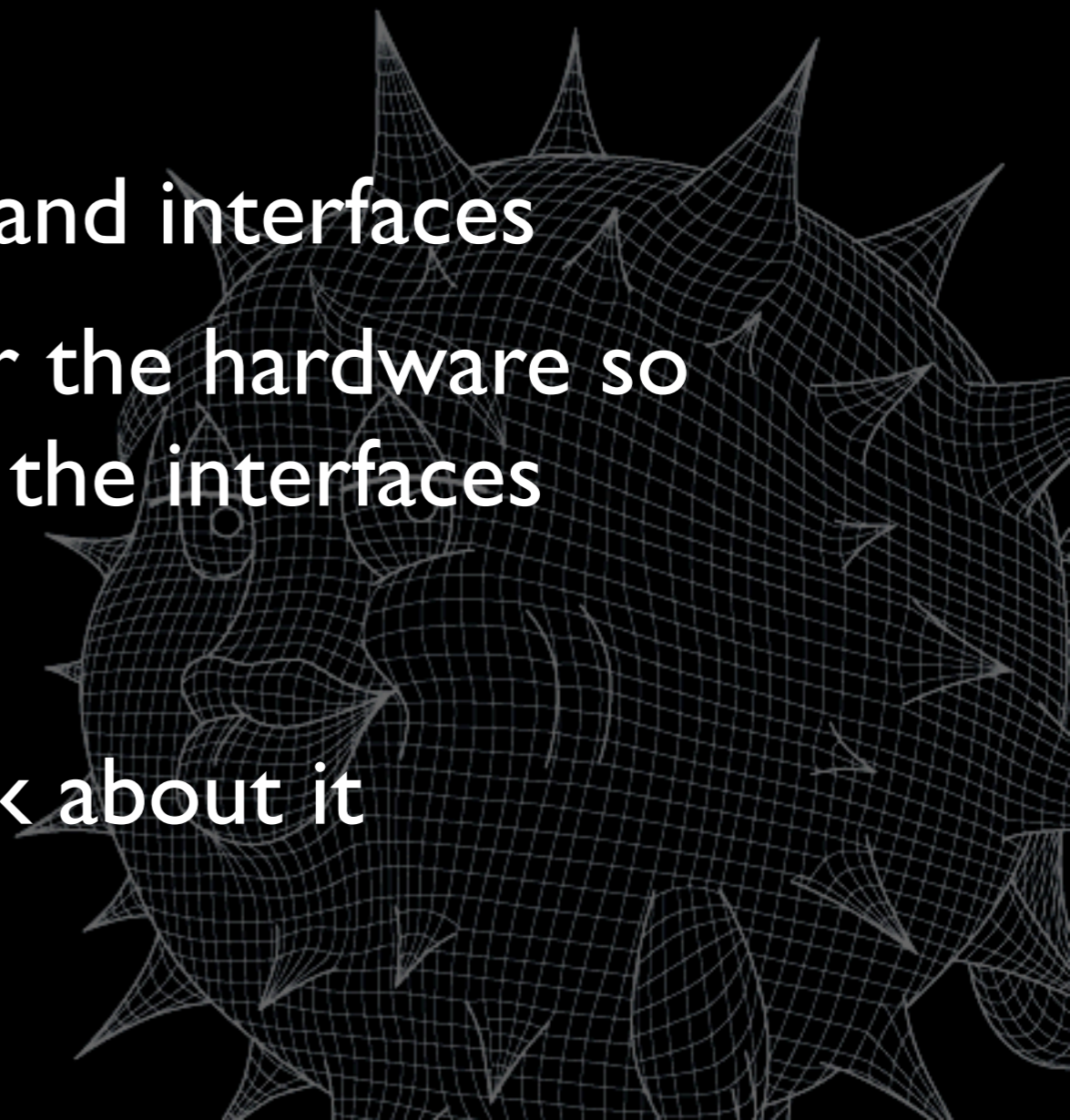
# what's the problem?

- every vendor implements tools to manage raid devices and sensors differently
  - these tools have evolved over the years into extremely complex and brittle stacks
  - open source operating systems seem merely content to boot on the hardware and let the vendor provide the monitoring
  - every implementation looks different
- 



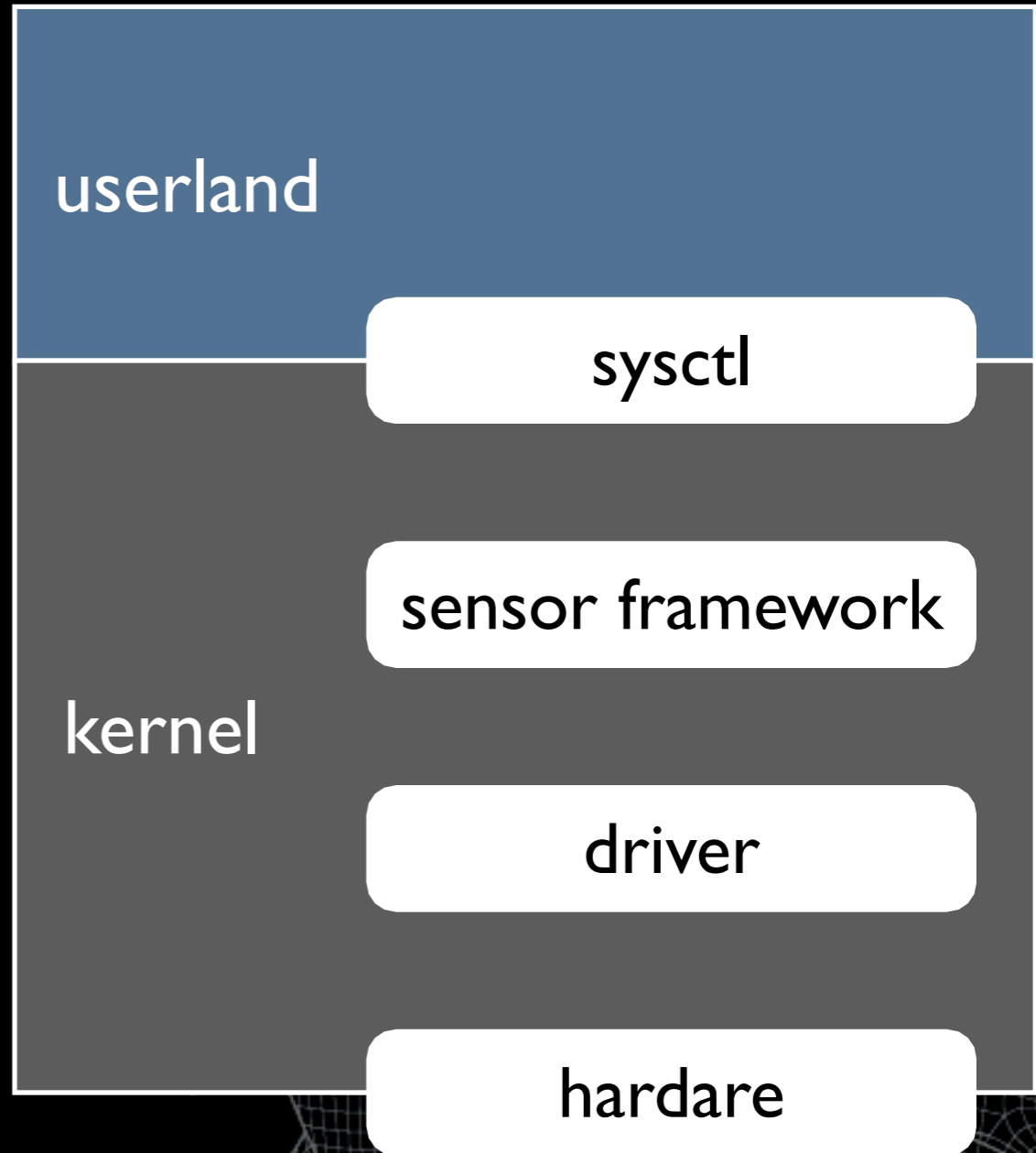
# what's the solution?

- take some responsibility and make our own
- more specifically:
  - define your own stack and interfaces
  - get the specification for the hardware so you can fit drivers into the interfaces
  - write the code
- fly to canada to give a talk about it



# sensors in depth

- sensors are a stack made up of:
  - the hardware
  - the driver
  - the sensor framework
  - sysctl
- all the smarts are in the sensor framework

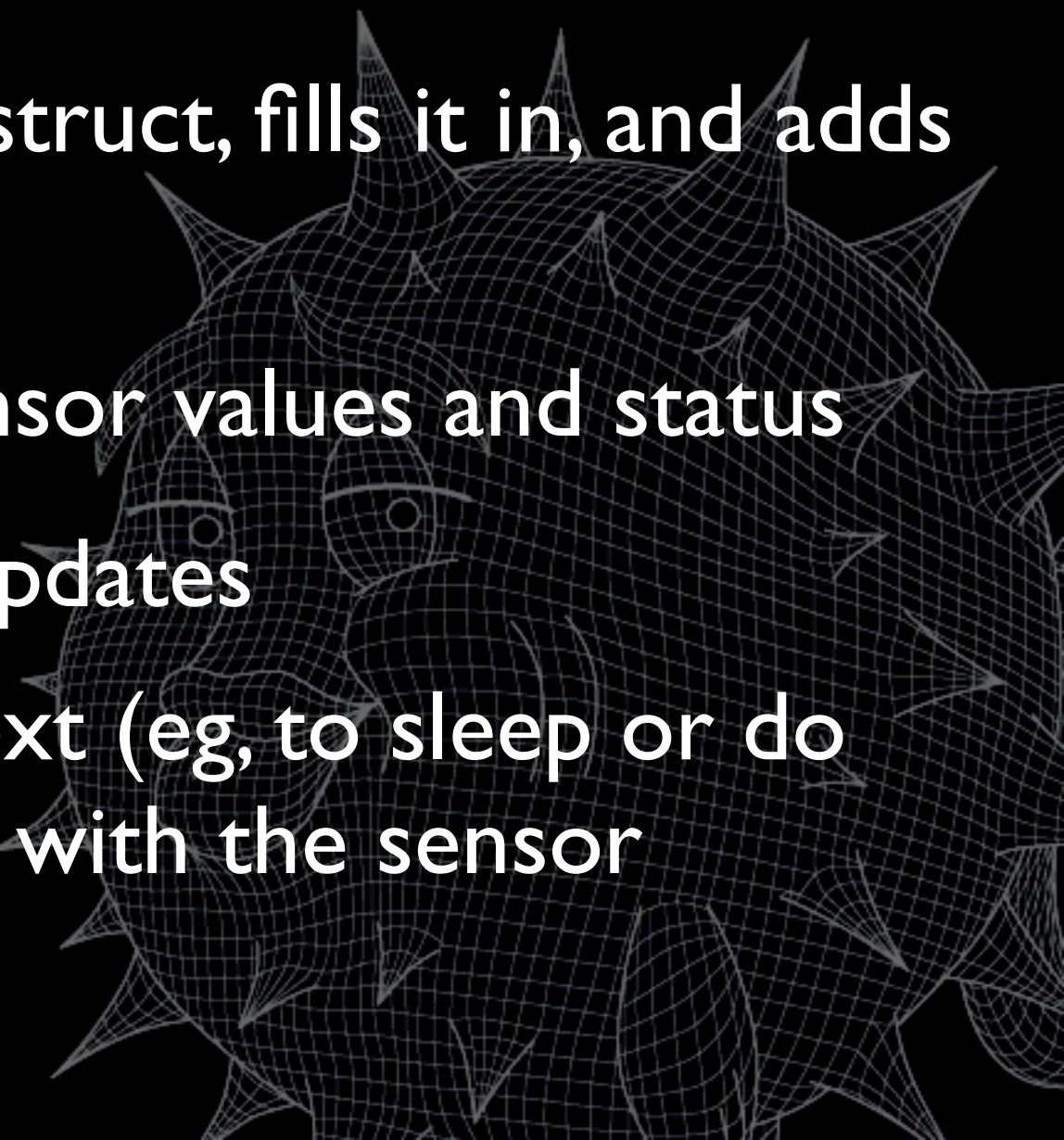




# sensor hardware

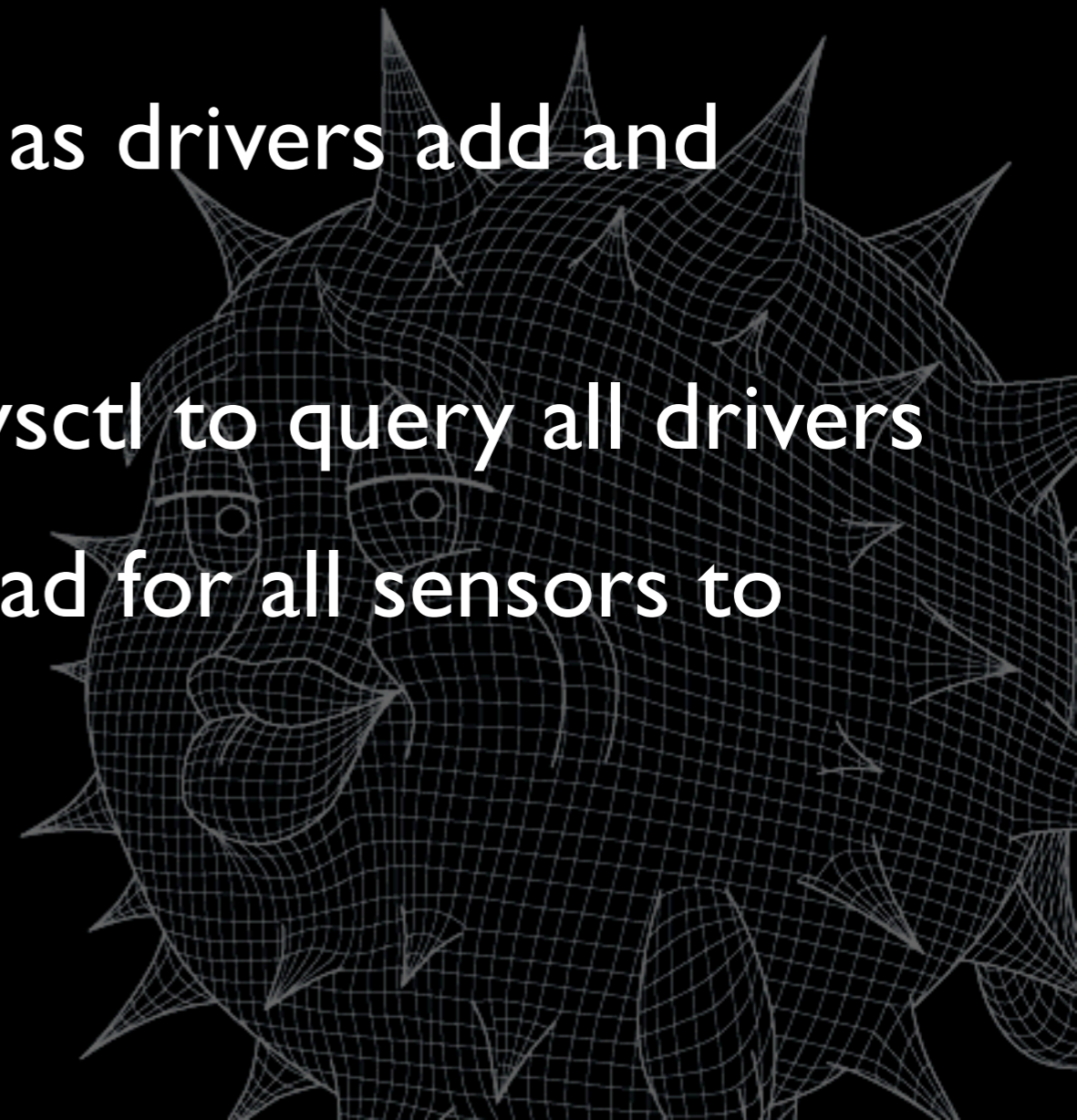
- we've found a lot of sensors
  - SCSI enclosures: ses, safte
  - system management controllers: ipmi, esm
  - I2C and SMBus devices: adc, admcts, adm1c, amdtemp, adm1m, adm1mp, adm1t, adt, asbtm, asms, fcu, glenv, lmenv, lmtmp, maxds, maxtmp, pcfadc, tsl, ...

# sensor drivers

- the driver is responsible for retrieving, interpreting, and normalising the sensor values off the hardware
  - the driver allocates a sensor struct, fills it in, and adds it to the sensor-framework
  - it periodically updates the sensor values and status
    - the driver can do its own updates
    - or if it needs process context (eg, to sleep or do DMA) it can register a task with the sensor framework
- 

# the sensor framework

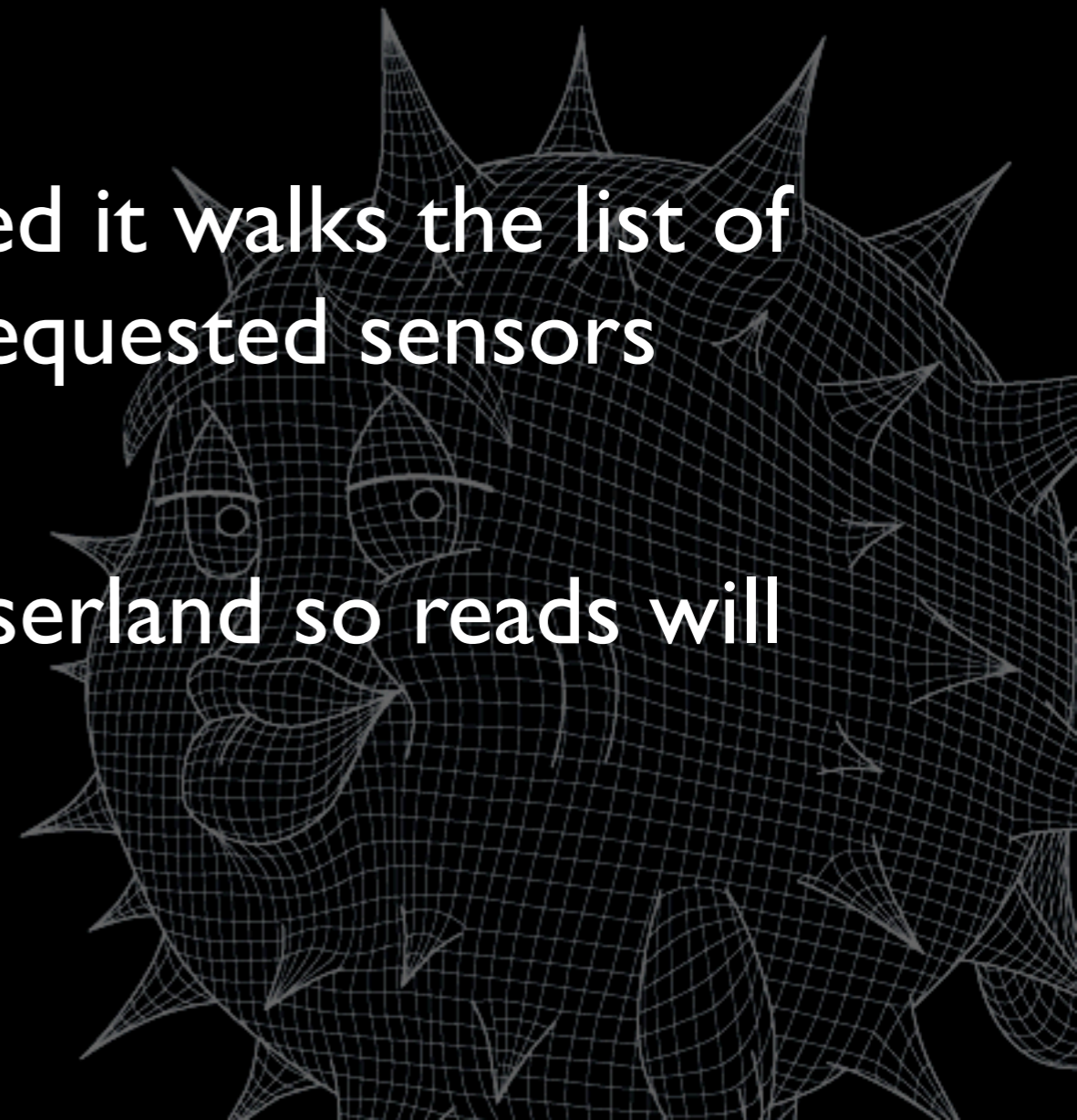
- maintains the list of sensors as drivers add and remove entries
- provides a single place for `sysctl` to query all drivers
- provides a single kernel thread for all sensors to update out of via callbacks





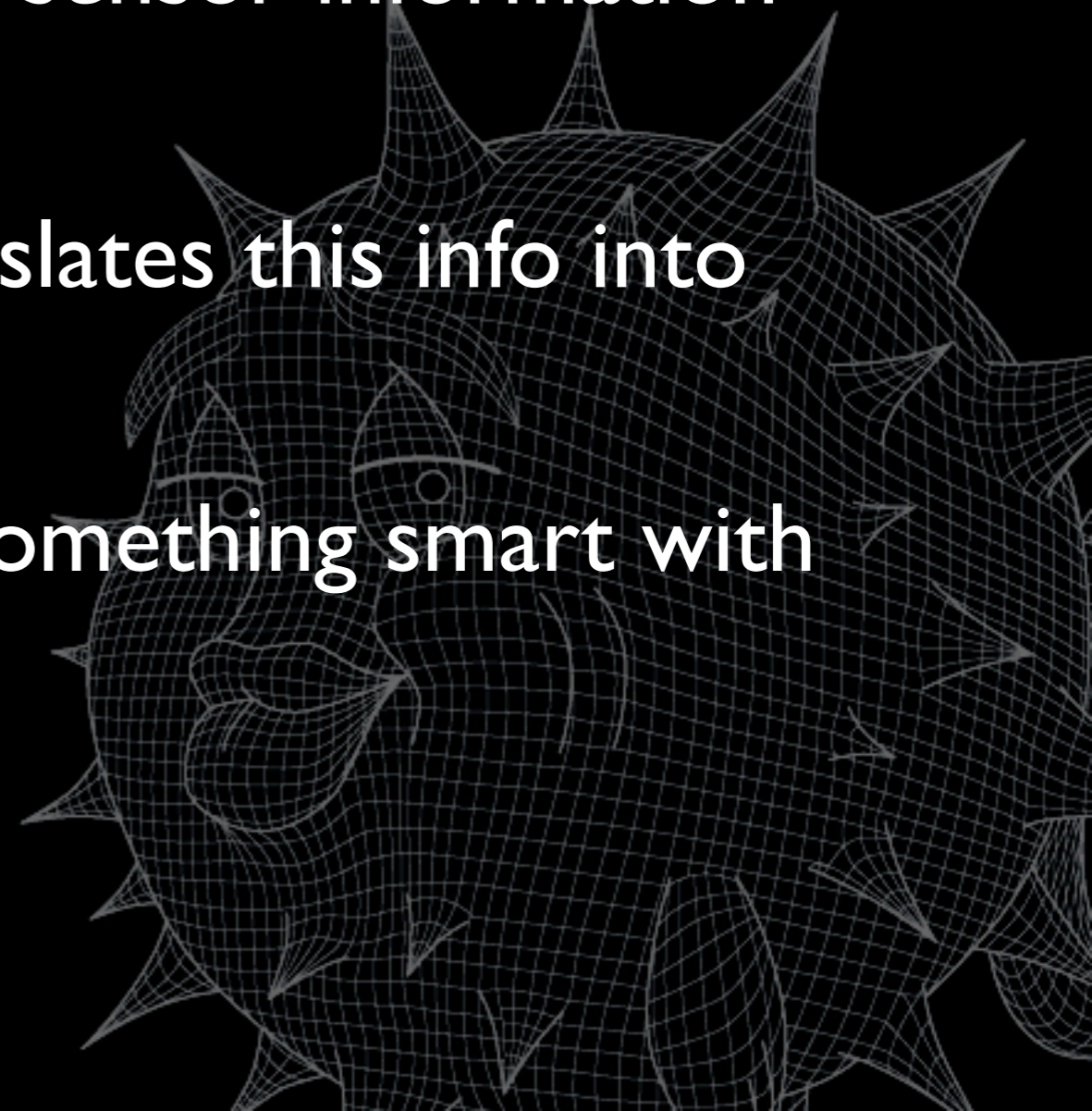
# sysctl

- the sysctl interface is where userland and kernel meet
- when the kernel is queried it walks the list of sensors and copies the requested sensors struct out to userland
- decouples updates and userland so reads will not block



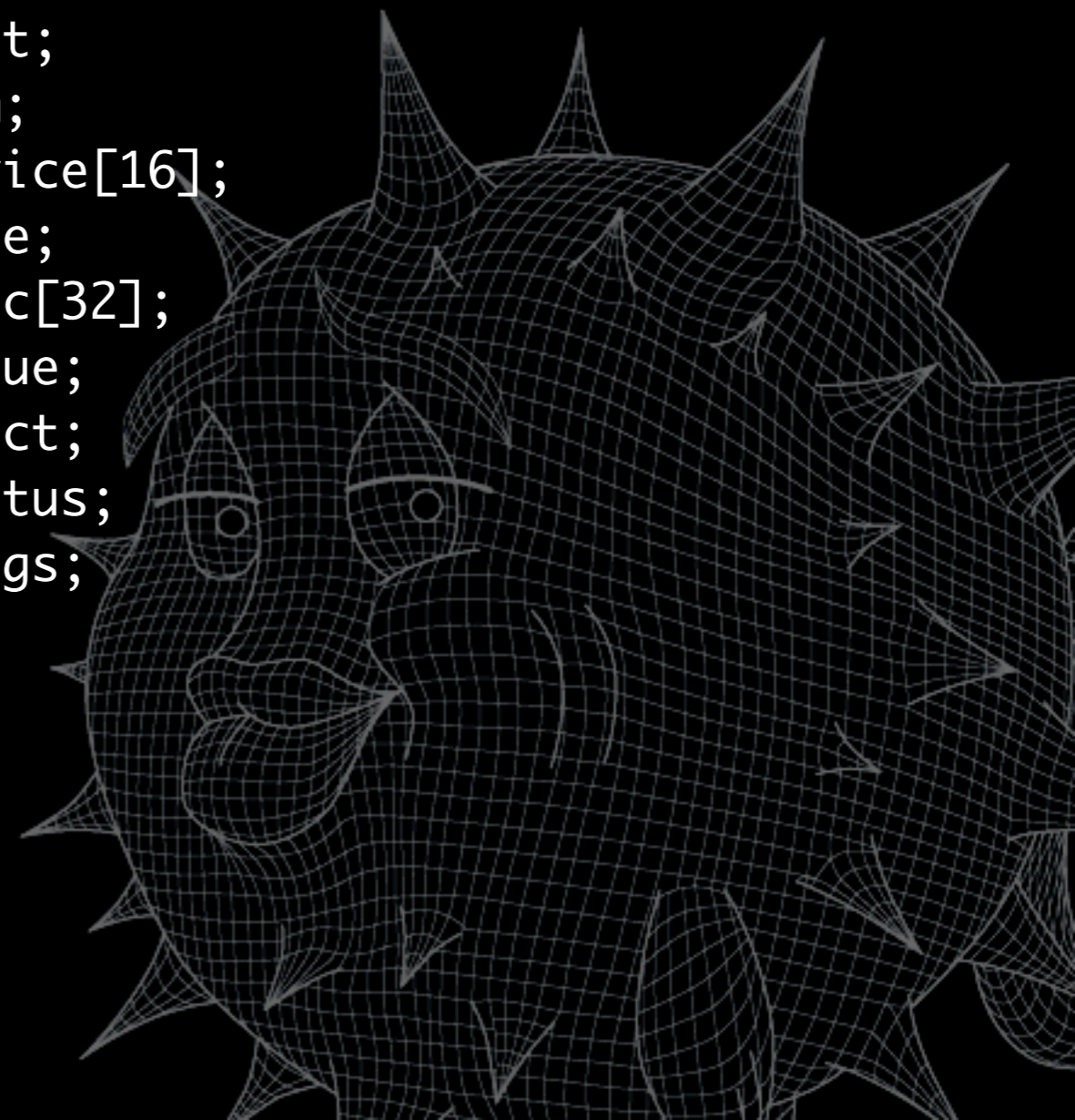
# sensors in userland

- userland gets the kernels sensor information via `sysctl(3)`
- `sysctl(8)` fetches and translates this info into human readable output
- `sensorsd(8)` tries to do something smart with it



# what a sensor looks like

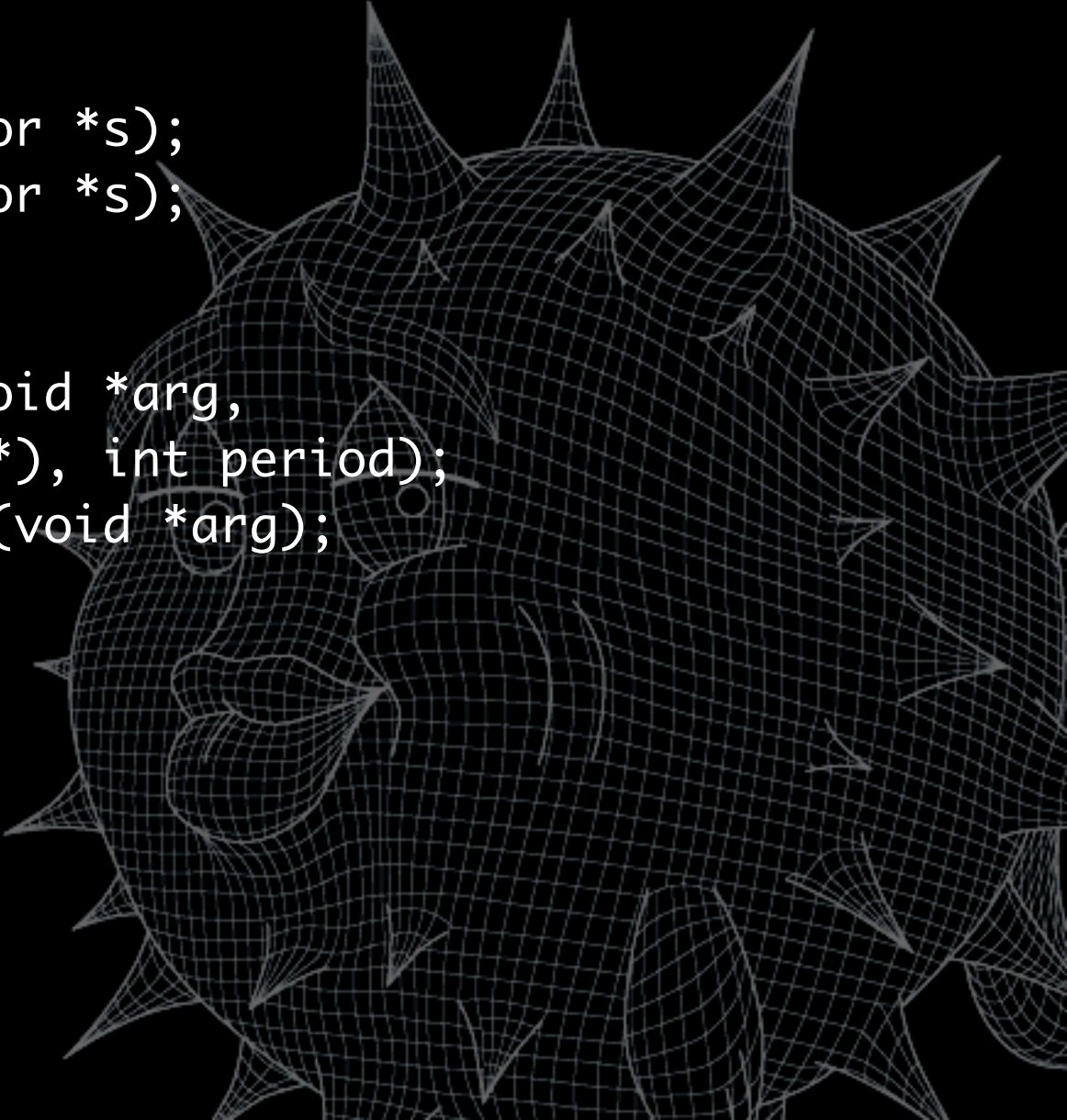
```
struct sensor {  
    SLIST_ENTRY(sensor) list;  
    int num;  
    char device[16];  
    enum sensor_type type;  
    char desc[32];  
    int64_t value;  
    u_int rfact;  
    enum sensor_status status;  
    int flags;  
    struct timeval tv;  
};
```





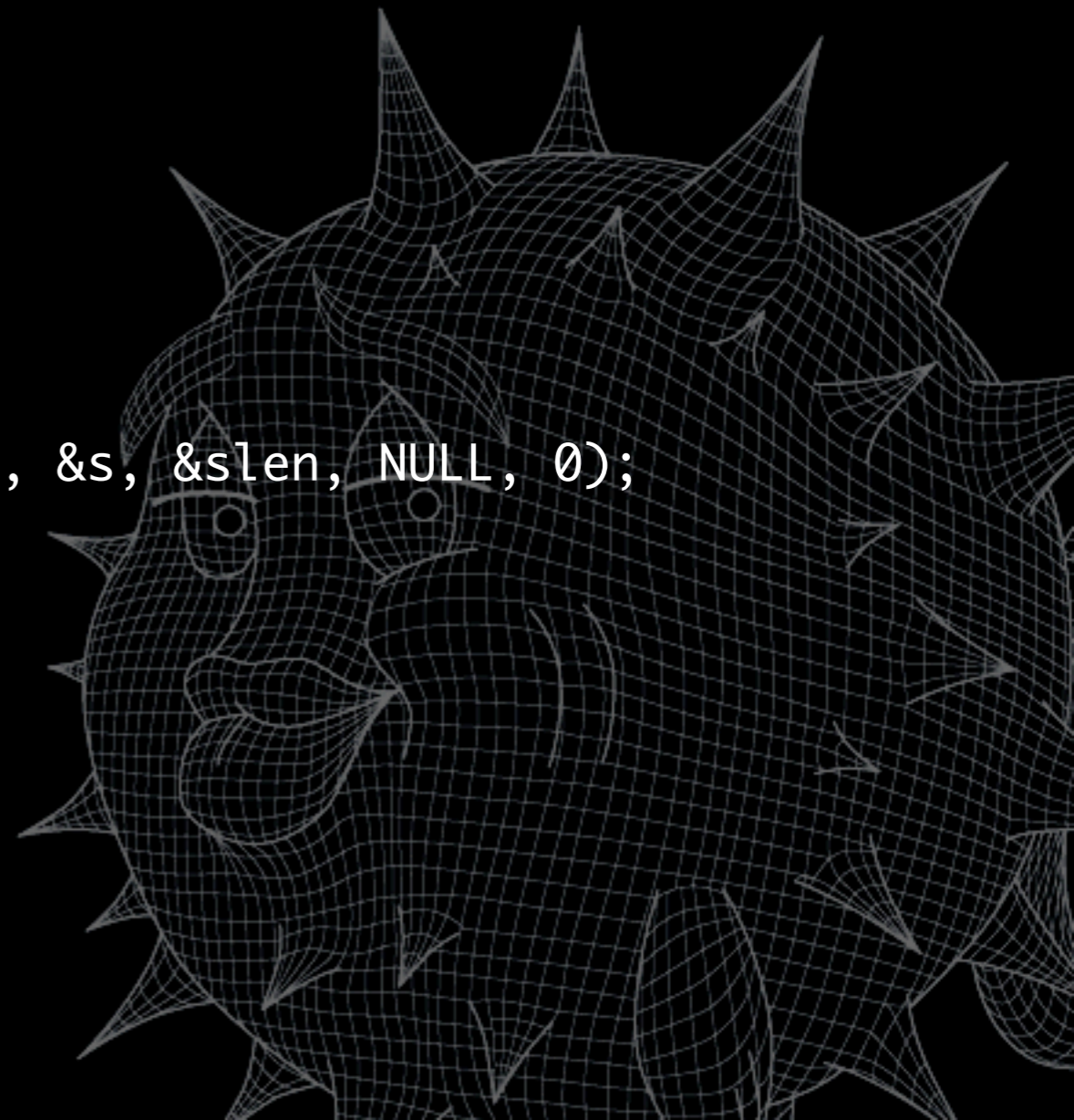
# sensors in the kernel

```
void          sensor_add(struct sensor *s);  
void          sensor_del(struct sensor *s);  
struct sensor *sensor_get(int id);  
  
int          sensor_task_register(void *arg,  
                                void (*func)(void *), int period);  
void          sensor_task_unregister(void *arg);
```



# sensors via sysctl(3)

```
int mib[] = { CTL_HW, HW_SENSORS, 0 };  
struct sensor s;  
size_t slen = sizeof(s);  
  
sysctl(mib, sizeof(mib)/sizeof(mib[0]), &s, &slen, NULL, 0);
```





# sensors via sysctl(8)

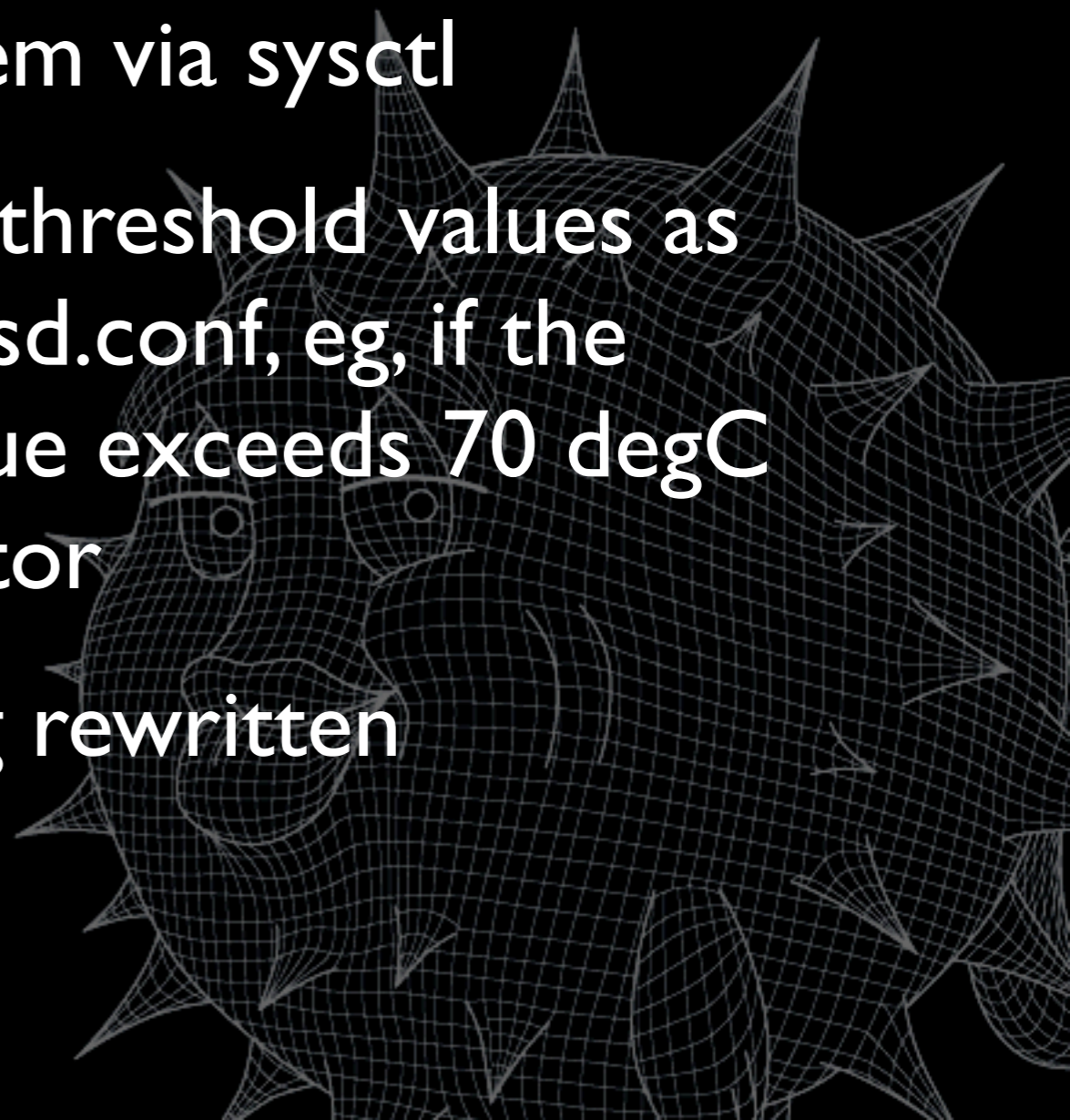
```
# sysctl hw.sensors
hw.sensors.0=ipmi0, Phys. Security, On, CRITICAL
hw.sensors.1=ipmi0, Baseboard 1.5V, 1.51 V DC, OK
hw.sensors.2=ipmi0, Baseboard 2.5V, 2.51 V DC, OK
hw.sensors.3=ipmi0, Baseboard 3.3V, 3.34 V DC, OK
hw.sensors.4=ipmi0, Baseboard 3.3Vsb, 3.49 V DC, OK
hw.sensors.5=ipmi0, Baseboard 5V, 5.10 V DC, OK
hw.sensors.6=ipmi0, Baseboard 12V, 12.10 V DC, OK
hw.sensors.7=ipmi0, Baseboard -12V, -12.30 V DC, OK
hw.sensors.8=ipmi0, Battery Voltage, 3.14 V DC, OK
hw.sensors.9=ipmi0, Processor VRM, 1.47 V DC, OK
hw.sensors.10=ipmi0, Baseboard Temp, 30.00 degC, OK
hw.sensors.11=ipmi0, Processor 1 Temp, 36.00 degC, OK
hw.sensors.13=ipmi0, Baseboard Fan 1, 1980 RPM, OK
hw.sensors.14=ipmi0, Baseboard Fan 2, 2100 RPM, OK
...
```





# sensorsd

- sensorsd polls the sensor values by periodically retrieving them via `sysctl`
- sensorsd can react upon threshold values as configured in `/etc/sensorsd.conf`, eg, if the ambient temperature value exceeds 70 degC then page the administrator
- currently awful, it is being rewritten



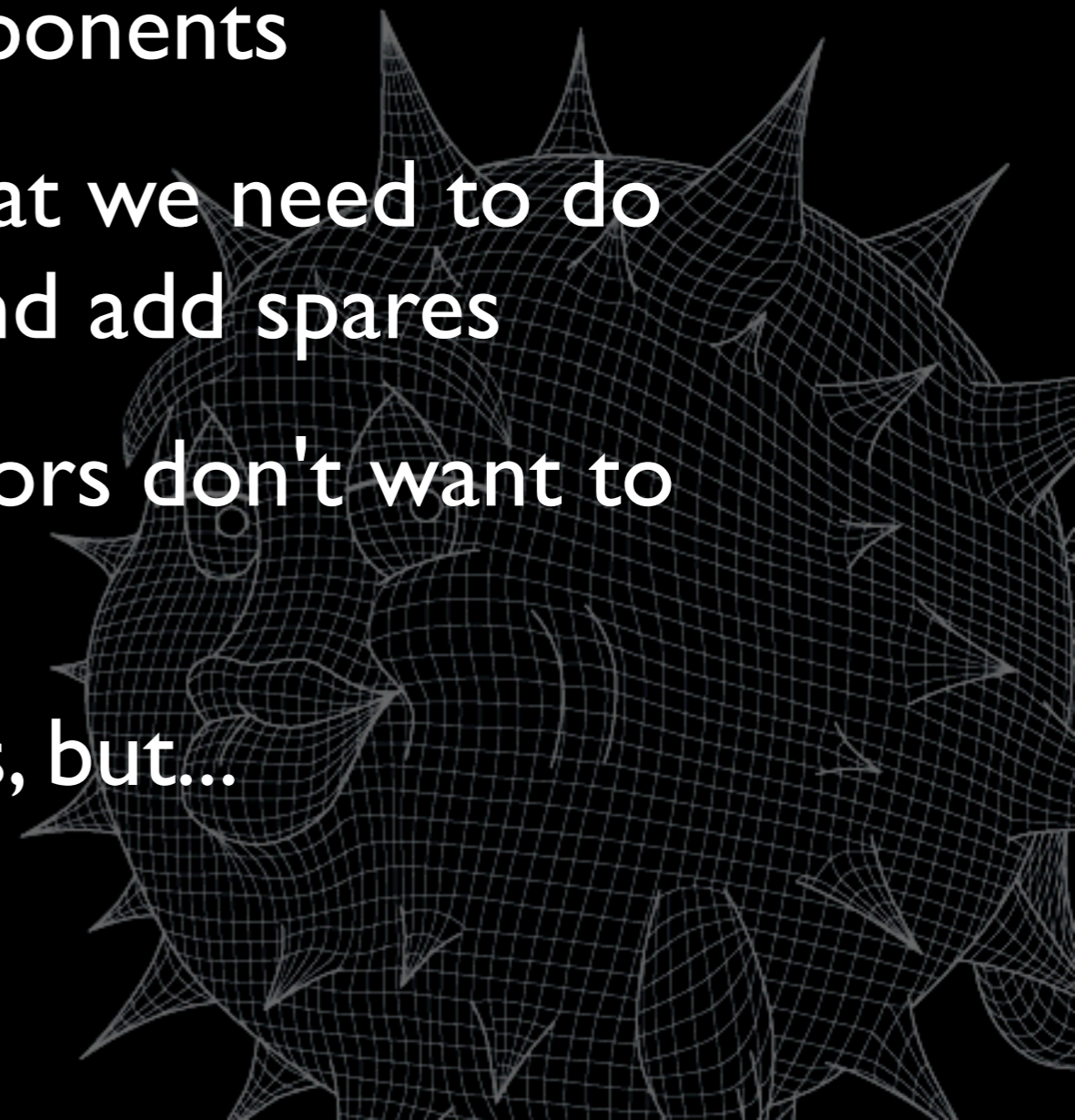
# sensors summary

- sensors are not magical, they're generally very simple, ie, read a value off hardware and stash it in a struct
- the same framework is enabled on all our archs (cept zaurus maybe)
- sensors are easy (and fun, like blinkenlights) to implement and use



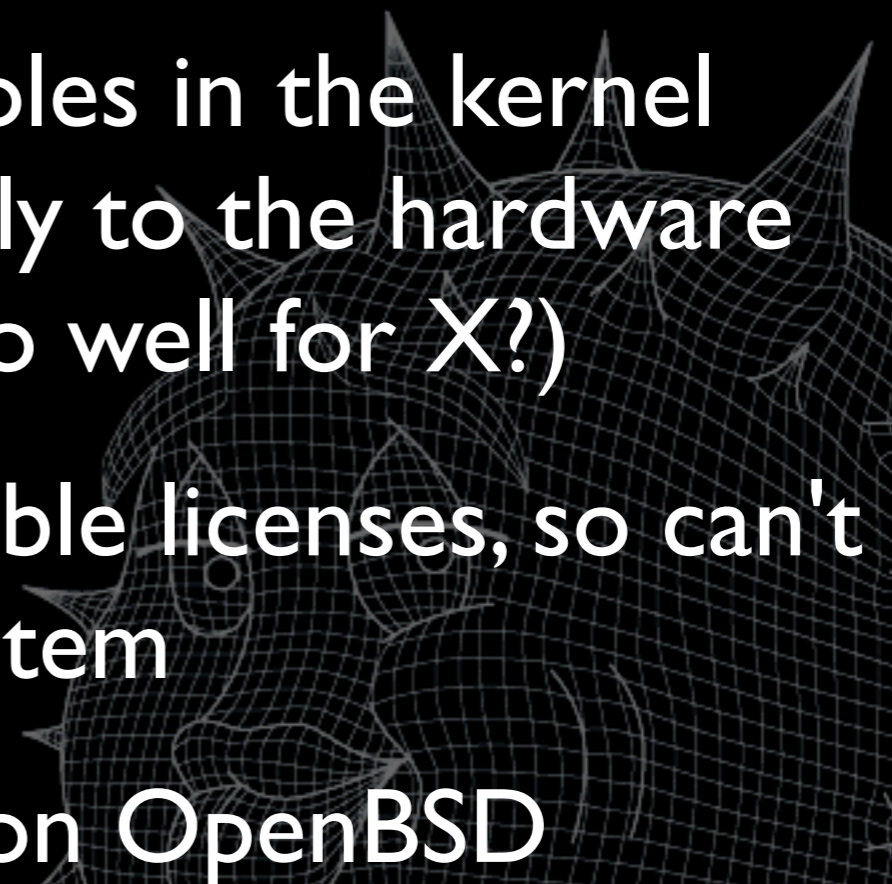
# RAID management

- similar to sensors in that we want to see the status of redundant components
- different to sensors in that we need to do more, eg, replace disks and add spares
- hard to do because vendors don't want to give up documentation
- vendors do provide tools, but...



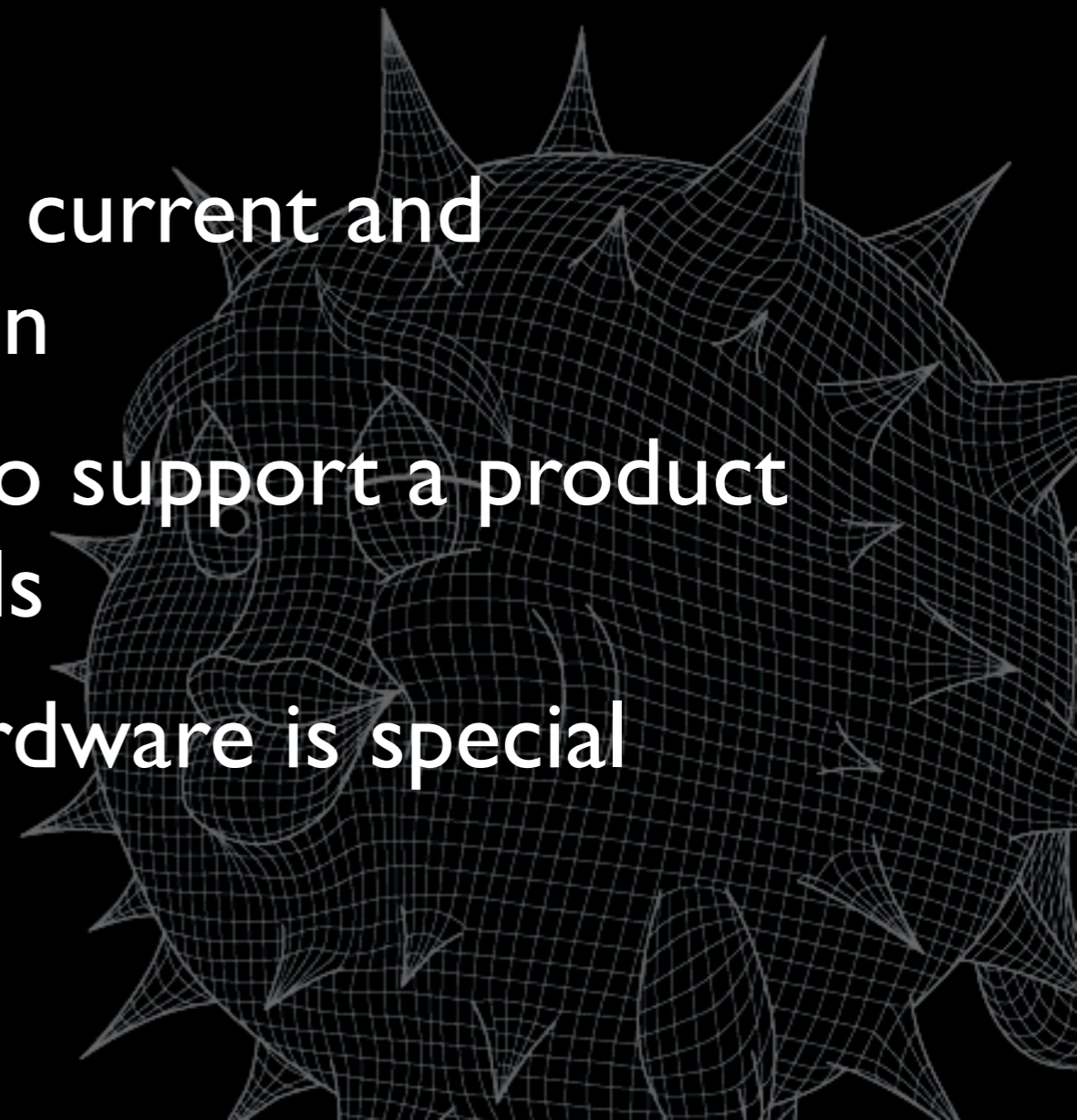


# vendor tools

- binary only, and limited to specific archs
  - requires us to open big holes in the kernel for userland to talk directly to the hardware (and hasn't that worked so well for X?)
  - provided under incompatible licenses, so can't be shipped in the base system
  - therefore not supported on OpenBSD
- 

# RAID documentation

- attempts to obtain documentation have failed for several reasons
  - Vendors do not possess current and accurate documentation
  - Vendors do not want to support a product beyond regular channels
  - Vendors think their hardware is special



# typical RAID management stack

- typically developed by different teams resulting in large amounts of abstraction
- the abstraction leads to bugs (more code always has more places for bugs to hide)
- different vendors have their own stacks

GUI

Agent

Library

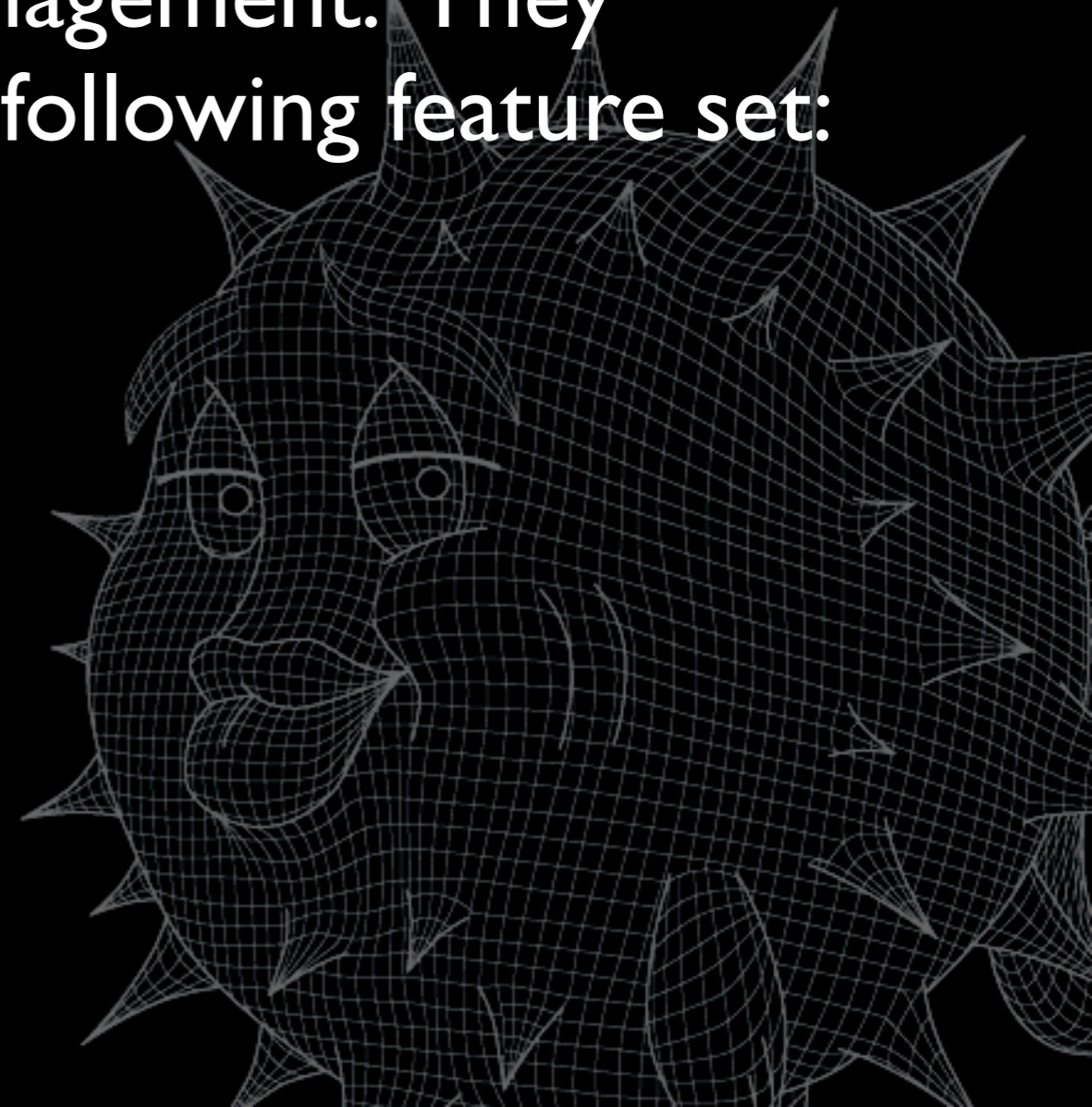
Driver

Firmware

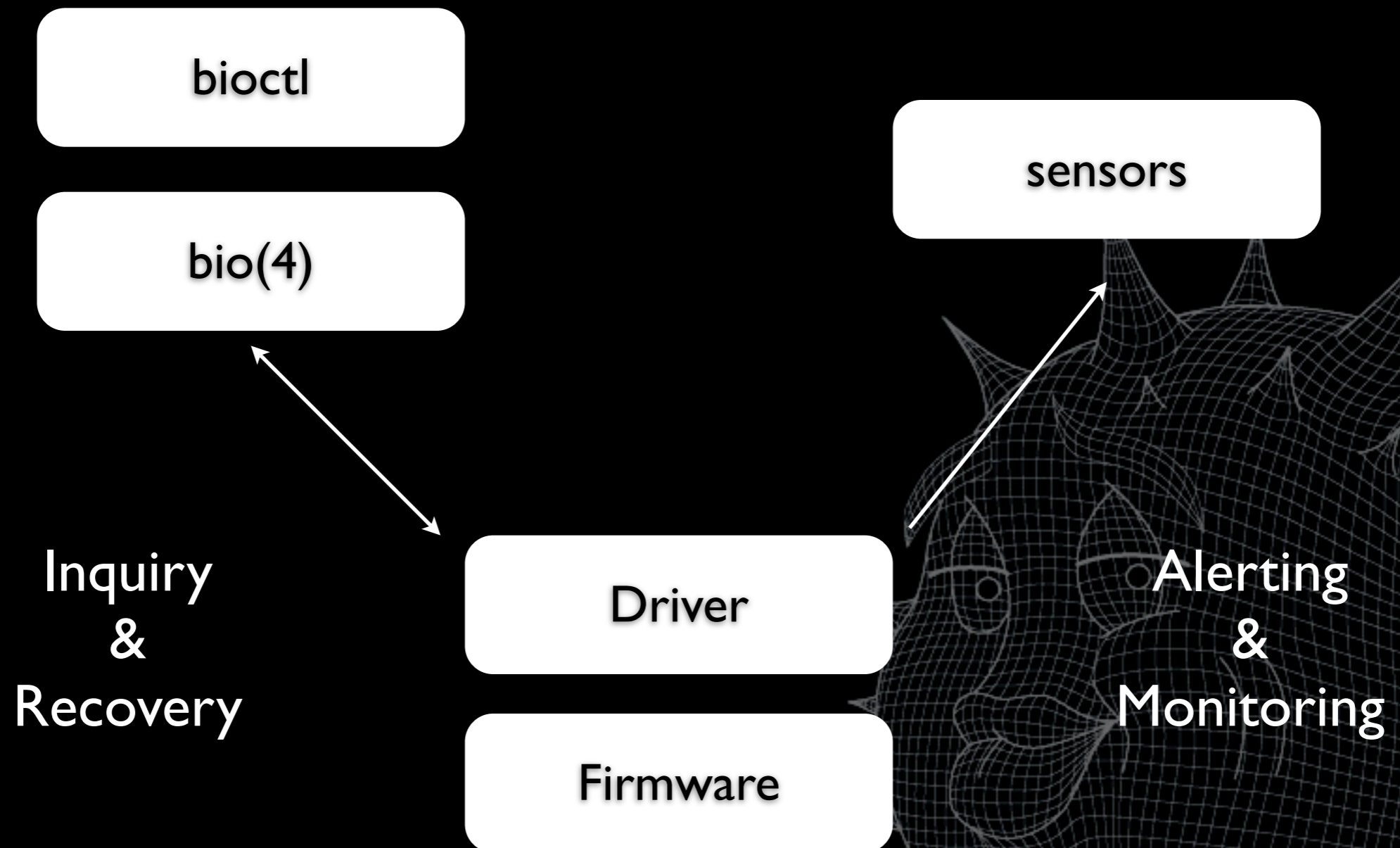


# RAID management essentials

- production machines do not need complex tool chains for RAID management. They essentially only need the following feature set:
  - alerts
  - monitoring
  - inquiry
  - recovery operations

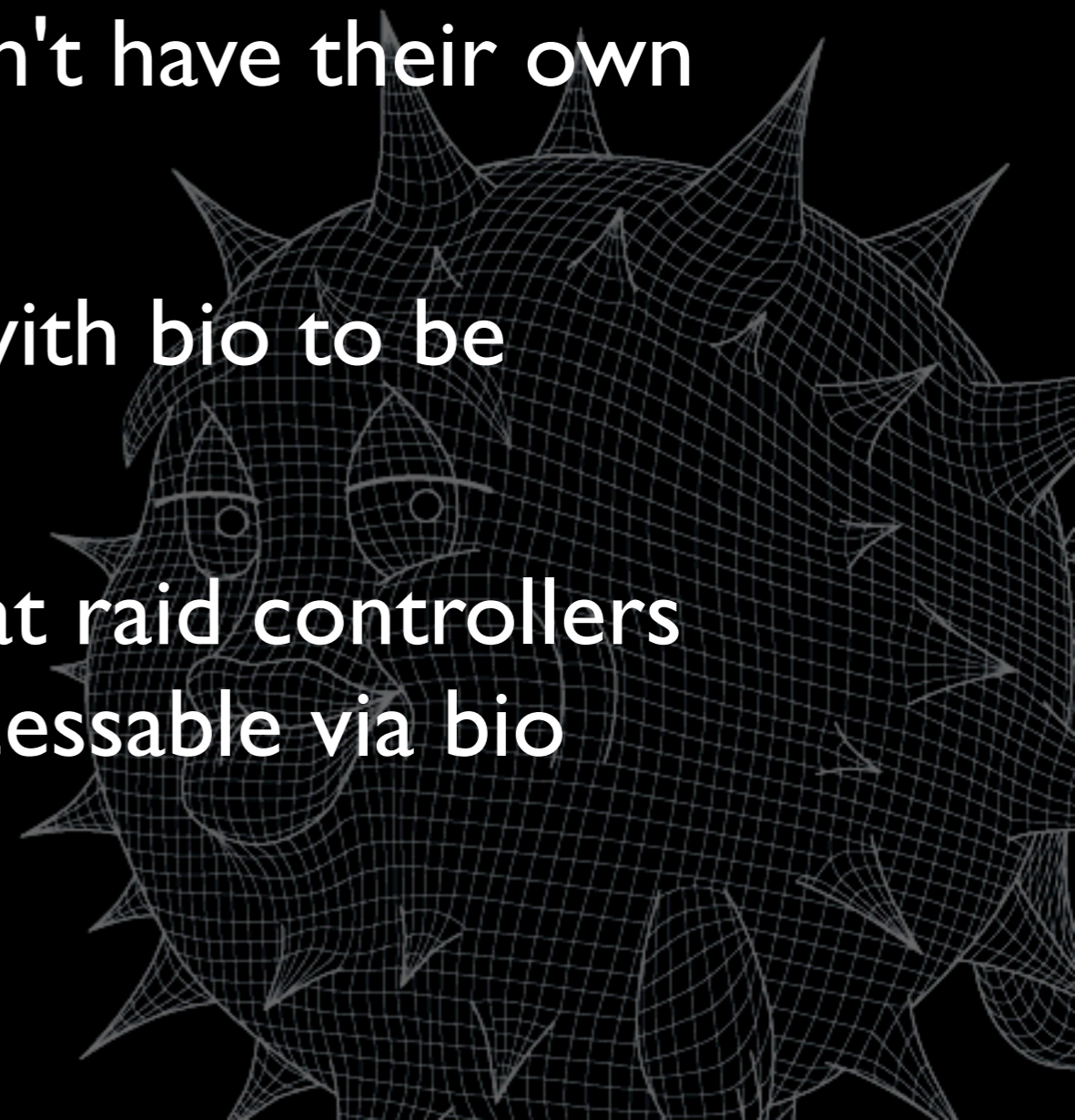


# OpenBSD RAID management



# bio(4)

- technically it is a pseudo device that tunnels ioctls for devices that don't have their own /dev entry
- drivers have to register with bio to be accessible via bio
- we define some ioctls that raid controllers can implement that is accessible via bio





# bio inside drivers

- In order to support bio drivers need to support some of the following ioctls:
  - BIOGINQ, BIOCDISK, BIOCVOL for enumeration of volumes and disks
  - BIOSETSTATE for adding spares
  - BIOCALARM, BIOCBLINK for finding the computer and the disks
- need a pass thru bus for access to phys bus

# bioctl

- bioctl is the userland half of our RAID management tool
- intended as the ifconfig of RAID controllers
- it translates the bio ioctls into something humans can grok



# bioctl

- inquiry functions:
  - display RAID setup and status
  - blink enclosure slot so you can find it
- recovery functions:
  - alarm management
  - create hot-spare
  - rebuild to hot-spare





# bioctl in action

```
# bioctl ami0
Volume Status      Size           Device
ami0 0 Online        366372454400 sd0      RAID5
      0 Online        73403465728 0:0.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      1 Online        73403465728 0:2.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      2 Online        73403465728 0:4.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      3 Online        73403465728 0:8.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      4 Online        73403465728 1:10.0  ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
      5 Online        73403465728 1:12.0  ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 1 Online        366372454400 sd1      RAID5
      0 Online        73403465728 0:1.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      1 Online        73403465728 0:3.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      2 Online        73403465728 0:5.0   ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
      3 Online        73403465728 1:9.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
      4 Online        73403465728 1:11.0  ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
      5 Online        73403465728 1:13.0  ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 2 Unused        73403465728 1:14.0  ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 3 Hot spare      73403465728 1:15.0  ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
```

# bioctl when we pull a disk

```
# bioctl ami0
Volume Status      Size      Device
ami0 0 Online         366372454400 sd0      RAID5
    0 Online         73403465728 0:0.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    1 Online         73403465728 0:2.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    2 Online         73403465728 0:4.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    3 Online         73403465728 0:8.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    4 Online         73403465728 1:10.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
    5 Online         73403465728 1:12.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 1 Degraded     366372454400 sd1      RAID5
    0 Online         73403465728 0:1.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    1 Online         73403465728 0:3.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    2 Online         73403465728 0:5.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    3 Rebuild        73403465728 1:15.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
    4 Online         73403465728 1:11.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
    5 Online         73403465728 1:13.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 2 Unused       73403465728 1:14.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
```



# bioctl when we return the disk

```
# bioctl ami0
Volume Status      Size      Device
ami0 0 Online        366372454400 sd0      RAID5
    0 Online        73403465728 0:0.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    1 Online        73403465728 0:2.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    2 Online        73403465728 0:4.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    3 Online        73403465728 0:8.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    4 Online        73403465728 1:10.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
    5 Online        73403465728 1:12.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 1 Degraded     366372454400 sd1      RAID5
    0 Online        73403465728 0:1.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    1 Online        73403465728 0:3.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    2 Online        73403465728 0:5.0    ses0    <MAXTOR ATLAS15K2_73SCA JNZ6>
    3 Rebuild       73403465728 1:15.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
    4 Online        73403465728 1:11.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
    5 Online        73403465728 1:13.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 2 Unused       73403465728 1:9.0    ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
ami0 3 Unused       73403465728 1:14.0   ses1    <MAXTOR ATLAS15K2_73SCA JNZ6>
```



# bioctl when we make it a spare

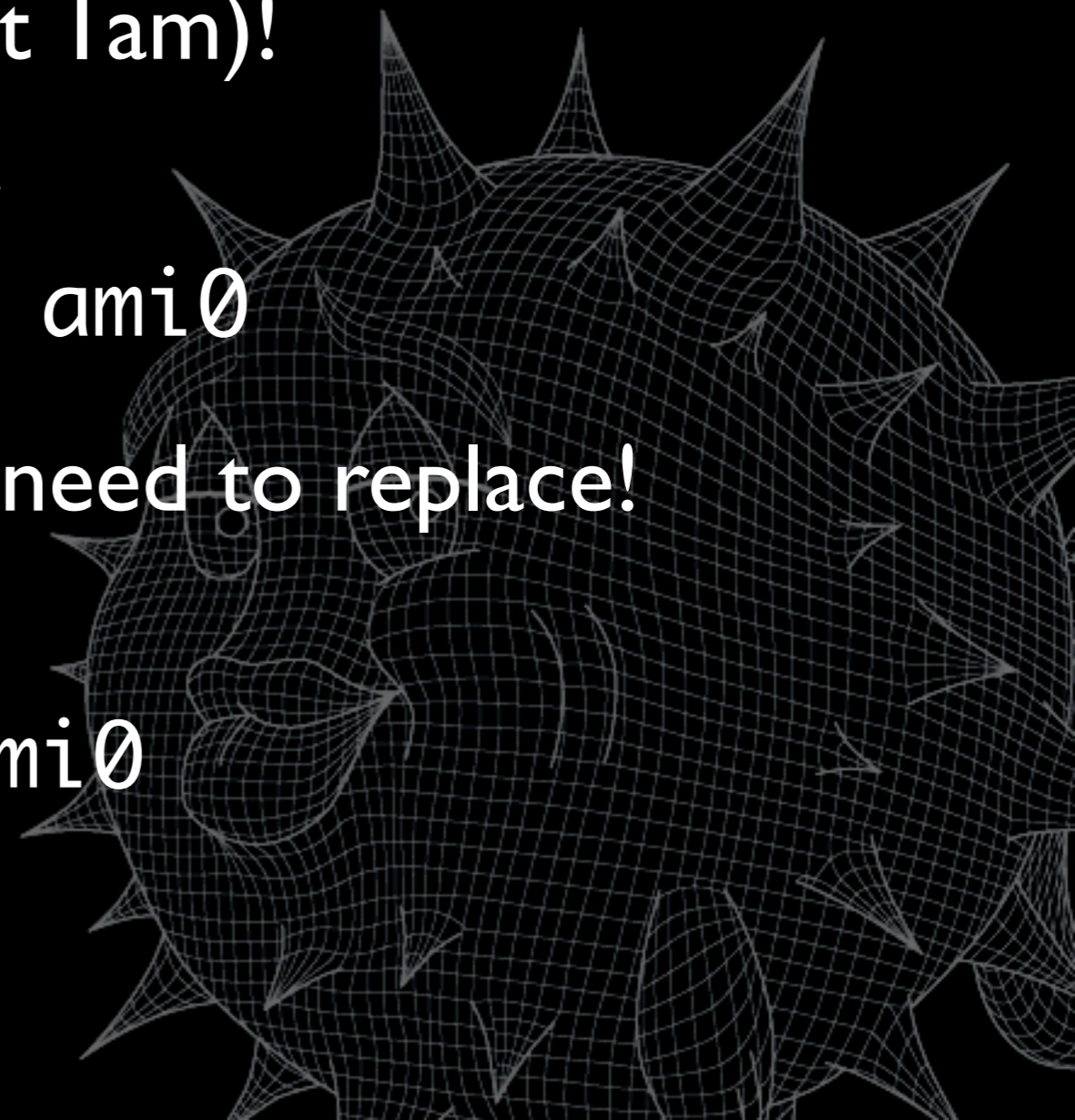
```
# bioctl -H 1:9 ami0
```

```
# bioctl ami0
```

| Volume | Status    | Size         | Device      |        |         |                 |                 |       |
|--------|-----------|--------------|-------------|--------|---------|-----------------|-----------------|-------|
| ami0 0 | Online    | 366372454400 | sd0         | RAID5  |         |                 |                 |       |
|        | 0         | Online       | 73403465728 | 0:0.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 1         | Online       | 73403465728 | 0:2.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 2         | Online       | 73403465728 | 0:4.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 3         | Online       | 73403465728 | 0:8.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 4         | Online       | 73403465728 | 1:10.0 | ses1    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 5         | Online       | 73403465728 | 1:12.0 | ses1    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
| ami0 1 | Degraded  | 366372454400 | sd1         | RAID5  |         |                 |                 |       |
|        | 0         | Online       | 73403465728 | 0:1.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 1         | Online       | 73403465728 | 0:3.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 2         | Online       | 73403465728 | 0:5.0  | ses0    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 3         | Rebuild      | 73403465728 | 1:15.0 | ses1    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 4         | Online       | 73403465728 | 1:11.0 | ses1    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
|        | 5         | Online       | 73403465728 | 1:13.0 | ses1    | <MAXTOR         | ATLAS15K2_73SCA | JNZ6> |
| ami0 2 | Hot spare | 73403465728  | 1:9.0       | ses1   | <MAXTOR | ATLAS15K2_73SCA | JNZ6>           |       |
| ami0 3 | Unused    | 73403465728  | 1:14.0      | ses1   | <MAXTOR | ATLAS15K2_73SCA | JNZ6>           |       |

# other bioctl magic

- help! i am bleeding from the ears (or waking people up when testing at 1am)!
- Disable the alarm with:  
# bioctl -a quiet ami0
- help! show me the disk i need to replace!
- Blink it with:  
# bioctl -b 1.9 ami0





# RAID and sensors

- along with temperatures and voltages, we have a type of sensor for reporting disk status
- provides near realtime information on the health of a RAID disk:

```
hw.sensors.0=sd0, ami0 0, drive online, OK  
hw.sensors.1=sd1, ami0 1, drive online, WARNING
```
- raid disks can be monitored like all other hw

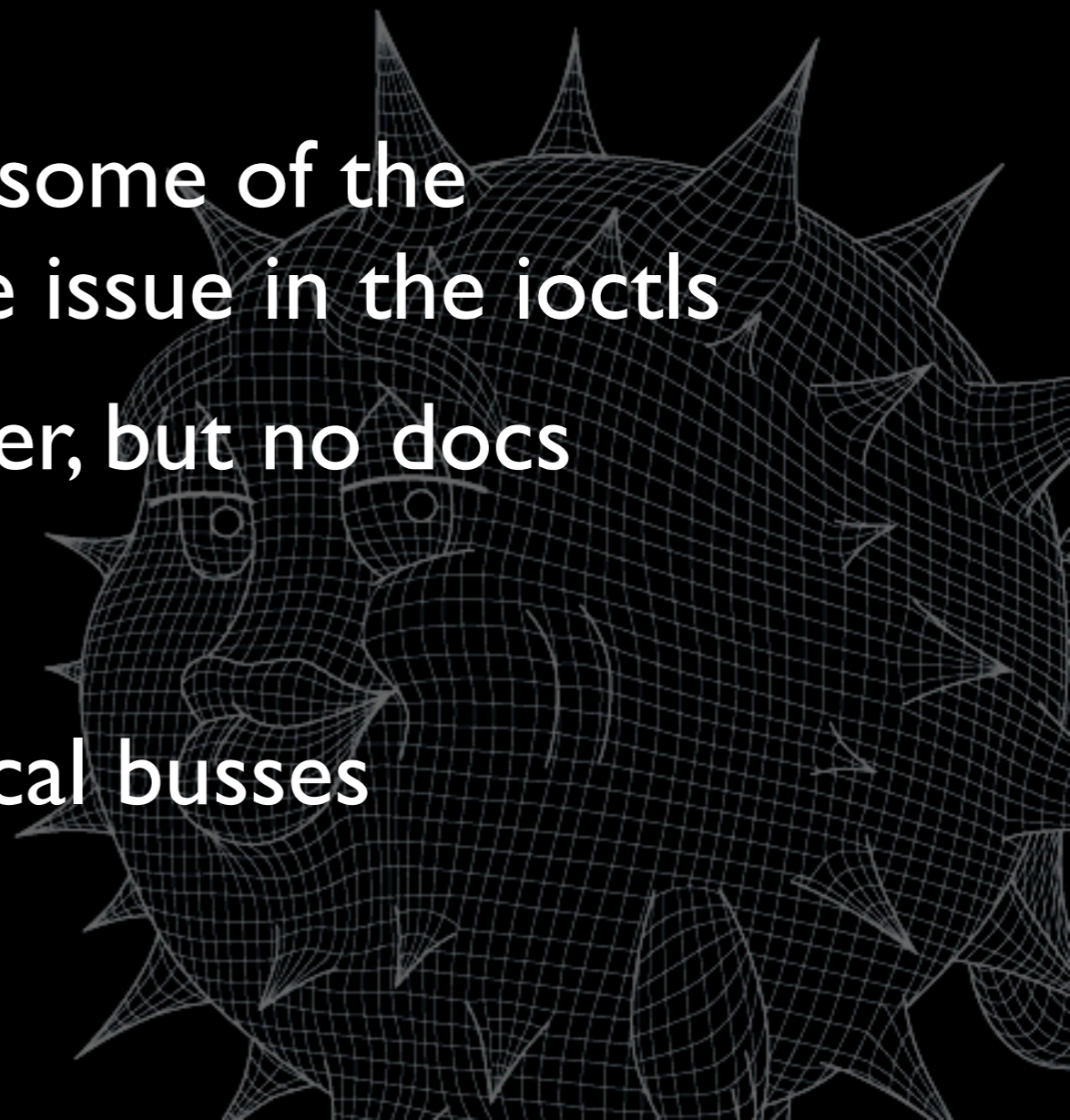


# SES and SAF-TE

- short for "SCSI Enclosure Services" and "SCSI Accessed Fault-Tolerant Arrays"
- they're needed for one main reason
  - SCSI does not support hot-plug without either one of these devices. in the above example the insertion of the disk in slot 1:9 would go undetected without an enclosure
- also provide normal temp/volt/etc sensors

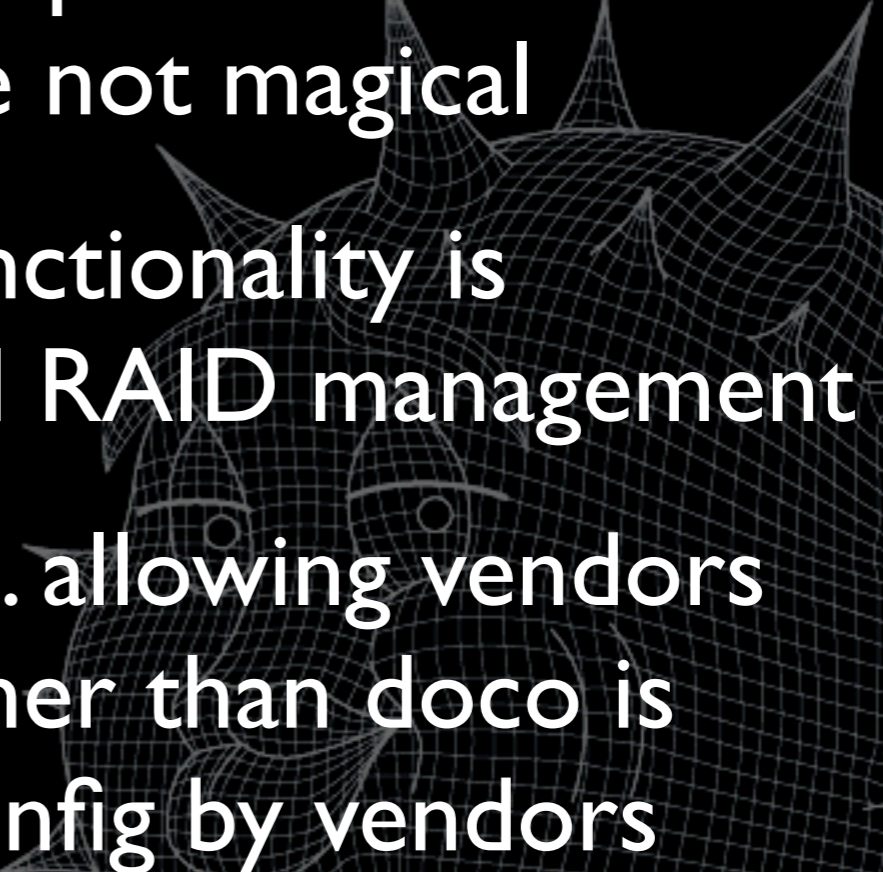
# supported hardware

- most SCSI and SATA based LSI/AMI MegaRAID cards
- older cards don't grok some of the MegaRAID inquiries we issue in the ioctl
- could probably do better, but no docs
- gdt(4) work has begun
- SES, SAF-TE on the physical busses



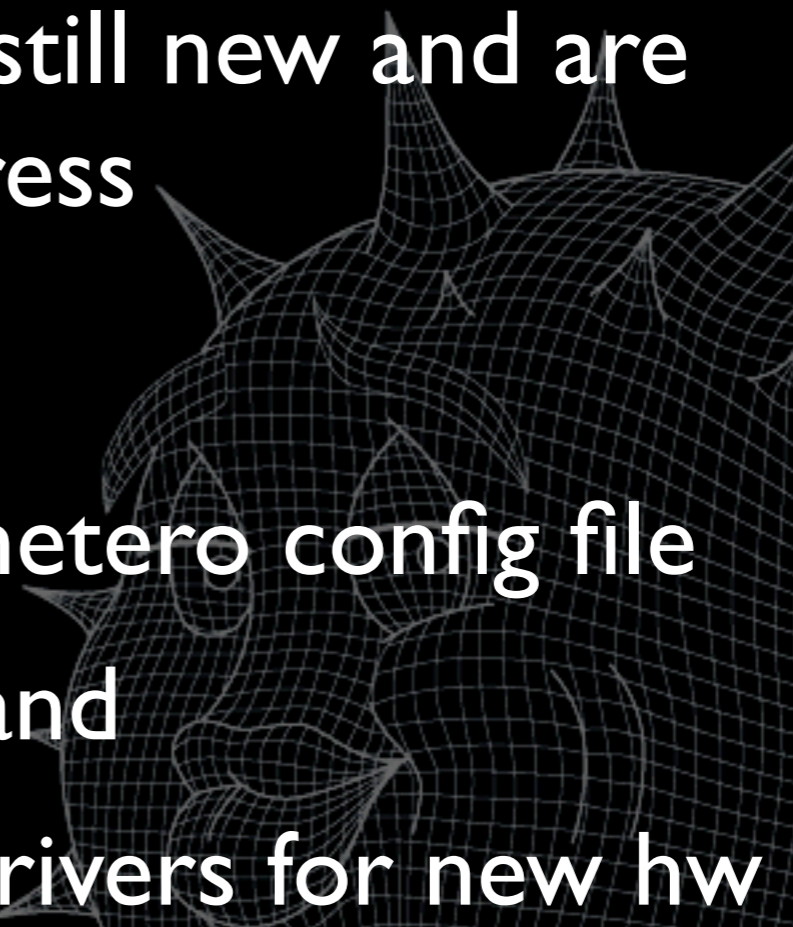


# conclusion

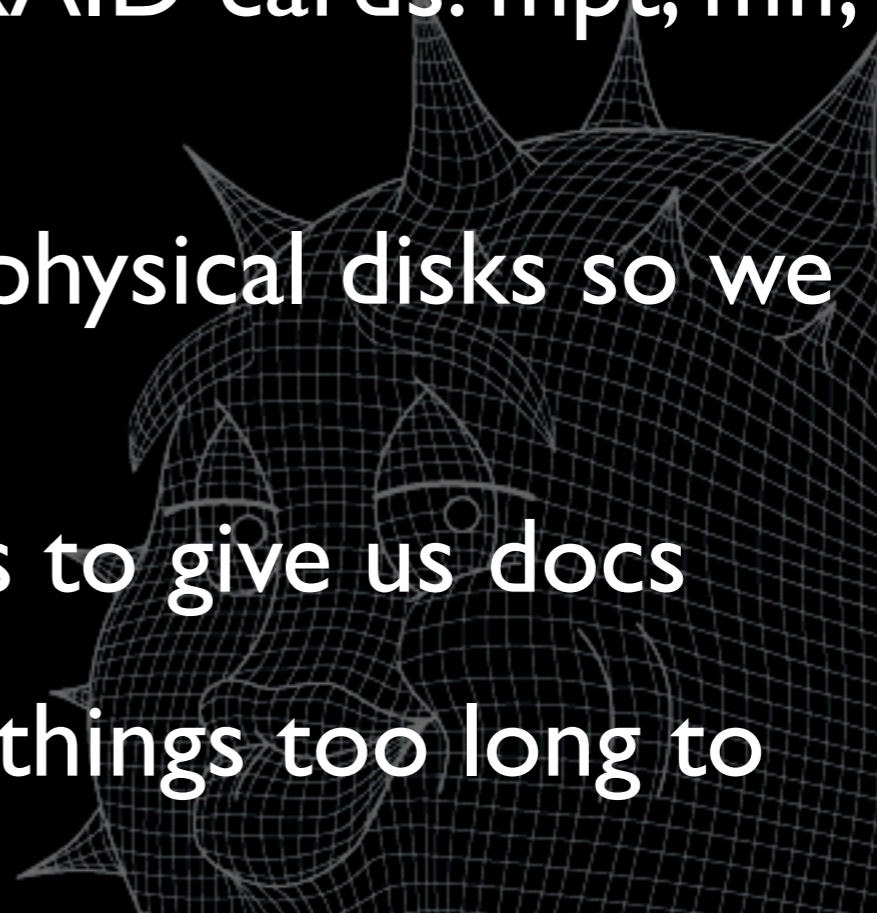
- RAID isn't some arcane voodoo (no chickens were harmed in the development of this software), and sensors are not magical
  - only a small amount of functionality is necessary to create useful RAID management
  - if we can do it, so can you. allowing vendors to provide their tools rather than doco is hurting users. imagine ifconfig by vendors
- 



# i have a dream... (the future)

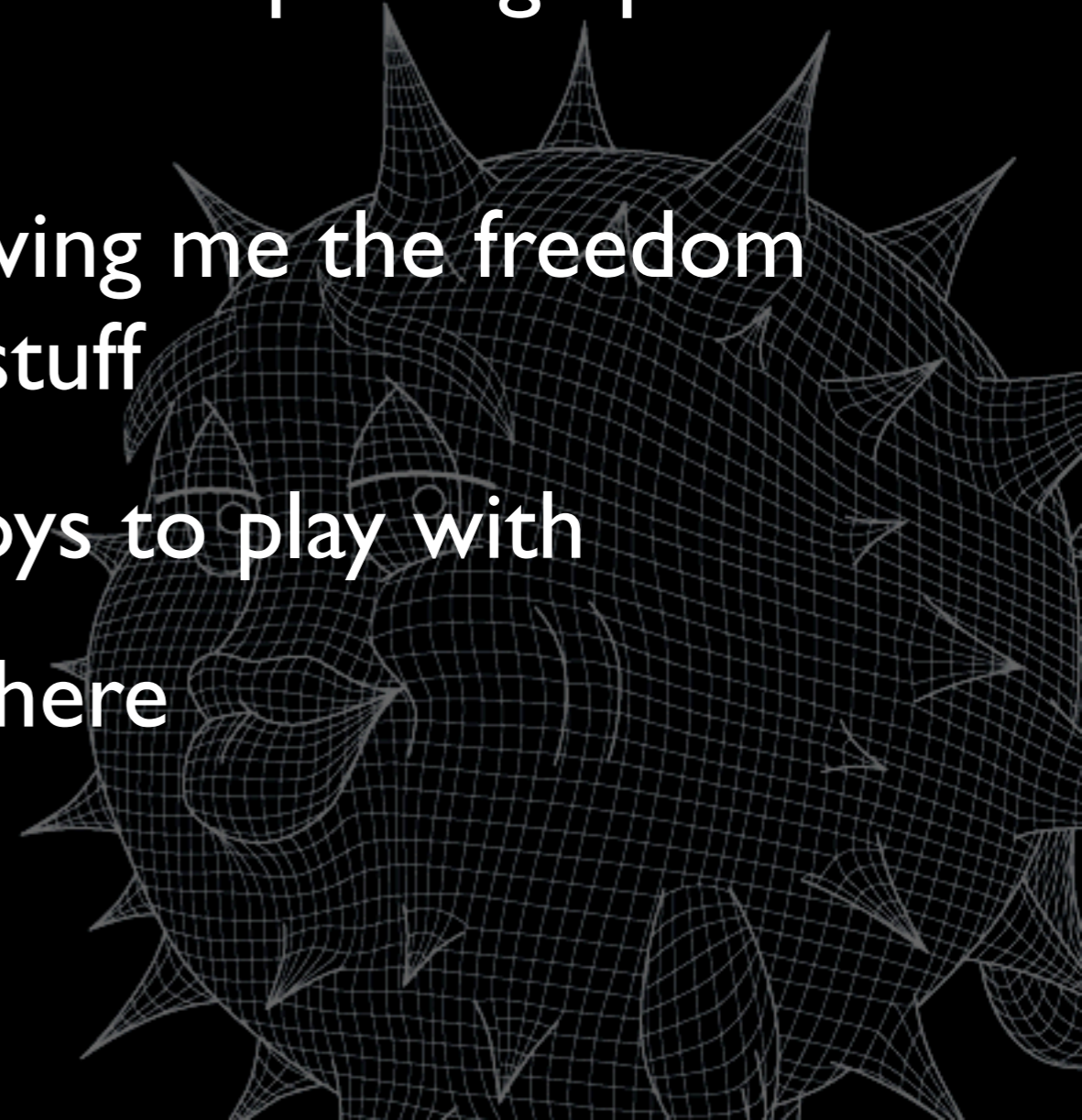
- i plan to never travel through the USA again
  - both sensors and bio are still new and are very much works in progress
  - for sensors
    - a new sensorsd with a hetero config file
    - sensors driven by userland
    - new sensor types and drivers for new hw
- 

# i have a dream... (the future)

- for bio
    - add support to other RAID cards: mpt, mfi, ciss for starters
    - S.M.A.R.T. support for physical disks so we can predict failure
    - convince more vendors to give us docs
    - a list of other associated things too long to display here
- 

# thx

- marco, krw, pascoe, deraadt for putting up with my stupid questions
- marco and deraadt for giving me the freedom to play around with this stuff
- donators for giving me toys to play with
- bsdcan for flying me out here





# pls help

- beck is pimping gear, find him if you want to help

