History of the OpenBSD Hardware Sensors Framework

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Outline

- Introduction
- Framework API and utilities
- Drivers
- I²C Bus Scan
- Summer of Code
- Conclusion

What is a sensor?

- Any device with a sensor-like data:
  - temperature
  - voltage
  - fan speed
  - ...
  - logical drive status
  - time offset

Are these common at all?

- many Super I/O chips have integrated hardware monitors
- Intel Core and AMD K8 / K10 have integrated thermal sensors
- IPMI in servers / ACPI in laptops
- SCSI enclosures
- 10GbE and 802.11

Why sensors framework?

- Monitoring environmental values can predict, detect, troubleshoot system failure.
  (Voltage, temperature, fan, logical drive status.)
- Unified interface, no configuration required, works out-of-the-box.
- Sensors are fun!

Drivers in 4.4 since 4.3

- 62nd driver: fins(4)
- 63rd: andl(4)
- 64th: kate(4)
- 65th: sdtemp(4) — JEDEC (JC -42.4) SO-DIMM
- 66th: adtfsm(4)
- 67th: km(4) — AMD Phenom, Opteron Barcelona
- 68th: vmt(4)

Latest drivers

- sdtemp(4) — SO-DIMM temperature sensors
- km(4) — AMD Family 10h processors (Phenom, Opteron Barcelona) and Family 11h (Turion X2 Ultra et al)

neither of these two are in Linux yet!

Design decisions

- Keep it simple, secure and usable
- Make it work by default
- Overengineering is useless — many devices have incomplete specifications
- No buttons™

How voltage sensors work?

- Most chips have sensors from 0 to 4 V
- Excess voltage removed by resistors
- Resistor “recommendations”

How voltage sensors read?

function	*maths*	*result*
original readin'	0xcb	203
sensor voltage	203 * 16 mV	3.24 V
scale for +5 V	3.24 V * 1.68	5.44 V
scale for +12 V	3.24 V * 3.80	12.31 V

Resister recommendations

- Ignored by some motherboard designers
- Not given in documentation for some chips

- Results:
  - voltage “doesn’t scale”
  - do the best with what you have

Framework API

/sys/sys/sensors.h

- struct sensor / struct sensordev, transport over sysctl(3)
  - sensor description, e.g. “CPU” (optional)
  - sensor type / unit: ‘temp’, ‘fan’, ‘volt’, ‘indicator’, ‘drive’, ‘timedelta’ etc
  - sensor state: unspec, ok, warn, crit, unknown

struct sensor / sensordev

```
struct sensor {
   char desc[32];        /* sensor description, may be empty */
   struct timeval tv;    /* sensor value last change time */
   int64_t value;        /* current value */
   enum sensor_type type;    /* sensor type */
   enum sensor_status status;  /* sensor status */
   int numt;             /* sensor number of .type type */
   int flags;            /* sensor flags */
};


struct sensordev {
   int num;              /* sensordev number */
   char xname[16];       /* unix device name */
   int maxnumt[SENSOR_MAX_TYPES];
   int sensors_count;
};
```

Adding sensors in attach()

```
void
drv_attach(struct device *parent, struct device *self, void *aux)
{
   ...

   strlcpy(sc->sc_sensordev.xname, sc->sc_dev.dv_xname,
       sizeof(sc->sc_sensordev.xname));

   for (i = 0; i < n; i++) {
      sc->sc_sensors[i].type = SENSOR_TEMP;
      sensor_attach(&sc->sc_sensordev, &sc->sc_sensors[i]);
   }

   if (sensor_task_register(sc, drv_refresh, 5) == NULL) {
      printf(": unable to register the update task\n");
      return;
   }

   sensordev_install(&sc->sc_sensordev);

   printf("\n");
}
```

Sensor task refresh procedure

```
void
drv_refresh(void *arg)
{
   struct drv_softc *sc = arg;
   struct ksensor   *s = sc->sc_sensors;
   ...

   for (i = 0; i < n; i++)
      s[i].value = ...;
}
```

Sensor tools in OpenBSD

- sysctl(3) HW_SENSORS / sysctl(8) hw.sensors
- systat(1) — semi-realtime sensor monitoring
- sensorsd(8) — sensor monitor
- ntpd(8) — timedelta minimiser
- snmpd(8) — SNMP daemon
- ports/sysutils/symon — remote monitoring

% sysctl hw.sensors

```
hw.sensors.km0.temp0=50.50 degC
hw.sensors.it0.temp0=32.00 degC
hw.sensors.it0.temp1=45.00 degC
hw.sensors.it0.temp2=92.00 degC
hw.sensors.it0.fan0=2528 RPM
hw.sensors.it0.volt0=1.34 VDC (VCORE_A)
hw.sensors.it0.volt1=1.92 VDC (VCORE_B)
hw.sensors.it0.volt2=3.42 VDC (+3.3V)
hw.sensors.it0.volt3=5.21 VDC (+5V)
hw.sensors.it0.volt4=12.54 VDC (+12V)
hw.sensors.it0.volt5=1.62 VDC (-5V)
hw.sensors.it0.volt6=4.01 VDC (-12V)
hw.sensors.it0.volt7=5.75 VDC (+5VSB)
hw.sensors.it0.volt8=3.23 VDC (VBAT)
```

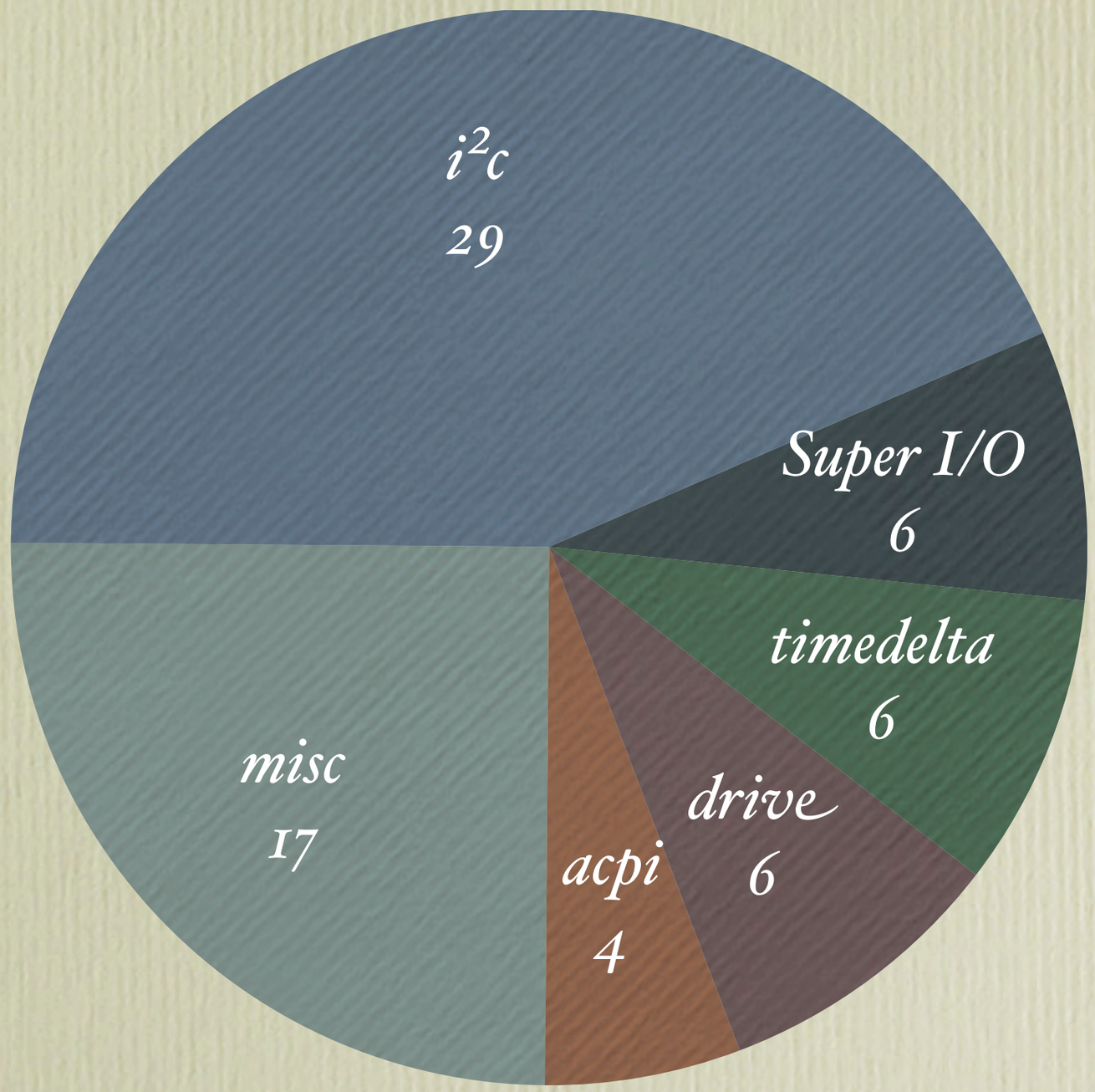
sensorsd

- fills in your logs
- no manual configuration required for ‘smart’ sensors (those that keep state)
- most other sensors require very minimal configuration (“temp:low=15C:high=65C”)

Drivers

- Super I/O hardware monitors (lm, it, viaenv, viasio, nsclpcsio, fins etc)
- SMBus hardware monitors (too many to mention)
- Embedded temperature sensors (Ethernet, CPU etc)
- SCSI enclosures and IPMI (safte, ses, ipmi, esm)
- Various ACPI sensors (temperature, voltage, power)
- RAID logical drive status sensors (esm, ami, ciss, mfi, arc, softraid)
- time offset sensors (“timedelta” sensors)

Drivers by type



Drivers

- OpenBSD 3.4 — 3 drivers (lm, it, viaenv)
- OpenBSD 3.5 — 4 drivers (..., nsclpcsio)
- OpenBSD 3.6 — 5 drivers (..., lmtemp)
- OpenBSD 3.7 — 5 drivers
- OpenBSD 3.8 — 9 drivers (..., aps, viasio, safte, ses)
- OpenBSD 3.9 — 33 drivers: huge number of i^2c sensors, i2c_scan, IPMI, drive status sensor introduced
- OpenBSD 4.0 — 42 drivers, timedelta introduced

Drivers

- OpenBSD 4.0-current as of 2006-12-23 — new framework revision, 44 drivers converted
- OpenBSD 4.1 — 46 drivers
- OpenBSD 4.2 — 51 drivers
- OpenBSD 4.3 — 61 drivers
- OpenBSD 4.4 — 68 drivers!

I²C

- Many chips lack meaningful signatures
- Open Firmware provides a list of devices (string, i²c-address pairs)
- Drivers match by string, e.g. “adt7467” or “ds1775”

I²C Bus Scan

/sys/dev/i2c/i2c_scan.c

- when there's no Open Firmware (e.g. i386/amd64/etc)
- goes through a list of i²c-addresses where sensors live
  - for each address, the value of each register is cached on the first read, unless it is ignored entirely via blacklisting
  - the result of successful scan iteration is a string describing the chip (e.g. "w83793g")

I²C Bus Scan (cont.)

- All signatures are located in i2c_scan.c, ensuring that there are no conflicts
- OpenBSD-way: all of this is enabled by default
- Result: code is tested on all machines that have i²c and don't have Open Firmware
- All supported i²c drivers are enabled in GENERICs and "just work"

I²C Sandbox

- i2c_scan.c prints a register dump for unidentified sensors into dmesg
- we kindly ask all users to voluntarily send dmesg's to dmesg@openbsd.org archive
- a sandbox driver wrapper can be easily written to parse the dumps, and test drivers
- streamlines i²c driver development and initial testing

NetBSD envsys / sysmon

- 31 drivers in NetBSD (vs. 68 in OpenBSD)
- more complicated API
- non-standard tools
- ‘drive’ sensors ported from OpenBSD
- 2007-11 envsys2 API introduced suspicious resemblance of OpenBSD’s sensor_attach API

Framework Timeline, Simplified

1999/2000: envsys / sysmon introduced into NetBSD, with lm(4) and viaenv(4)

2003-04-25: lm(4) and viaenv(4) are committed into OpenBSD by grange@ (Alexander Yurchenko), but with a much simpler sysctl-based interfacing, first appeared in OpenBSD 3.4

2004/2005: evolution by grange, dlg, kettenis and deraadt

2006-12-23: deraadt@ commits my patches, converting 44 device drivers and userland applications from one-level addressing to two-level addressing (e.g. hw.sensors.11 to hw.sensors.lm0.temp2)

2007-09-13: final GSoC2007/cnst-sensors patch released for FreeBSD 7.0-CURRENT

Porting to FreeBSD

- Last of day of SoC applications, looked at the FreeBSD ideas page by chance, seeing that someone has requested a port of the sensors framework
- Applied, talked with several people, got accepted

Summer of Code 2007

- Ported the sensors API and documentation
- Drivers: lm, it, coretemp
- Userland applications: sysctl, sensorsd, systat
- Fixed several small bugs here and there
- Fixed one 10-year-old bug in OpenBSD and another 12-year-old bug in FreeBSD

GSoC2007/cnst-sensors

- Complete final patch released on 2007-09-13, but FreeBSD HEAD still frozen
- Hasso Tepper mailed me on 2007-09-25 thanking me for the FreeBSD port, and saying that with small adaptations the work will be committed into DragonFly really soon — took me by surprise
- Committed to DragonFly on 2007-10-02

Sensors in FreeBSD CVS

- Approved by re@ and committed into FreeBSD 8.0-CURRENT by Alexander Leidinger (netchild@) on 2007-10-14, same week when RELENG_7 branch was created and the long-term code freeze of CVS HEAD was over
- Backed out on 2007-10-15 per phk request

Sensors in FreeBSD

- The SoC project was done to phk's satisfaction!
- However, few questions were posed:
  1. whether the framework is needed in FreeBSD in the first place
  2. whether this specific framework has a FreeBSD feel to it
- Huge discussions, many people liked it, many people hated it, others wanted more drivers.

Sensors in FreeBSD?

- separate sensors framework is less needed in FreeBSD due to phk's "sysctl magic"
    - many people still want it, though...
- userland vs. kernel argument
    - then why coretemp(4) and k8temp(4)?

Sensors in FreeBSD Finale

- "ported to FreeBSD, committed to DragonFly"
- gained a lot of experience with drivers
- thanks to syrinx, netchild, rpaulo, rwatson, sam and many others
- details on the 2007-09-13 patch are available at http://wiki.freebsd.org/GSoC2007/cnst-sensors

Conclusion

- 68 drivers in OpenBSD 4.4
- Framework is popular and in high demand
- Driver code is shared between NetBSD, OpenBSD, DragonFly BSD and FreeBSD
- Userland interface is compatible between OpenBSD and DragonFly BSD, and patched FreeBSD

Future Projects

- Write even more sensor drivers for OpenBSD (75+ drivers by OpenBSD 4.5?)
- Port sensors-detect.pl from lm_sensors
- Port i2c_scan.c to FreeBSD / DragonFly APIs
- Further improve sensorsd
- Fan-speed controlling

Questions?
Comments?

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