The Power Supply Subsystem

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- Open Source contributor
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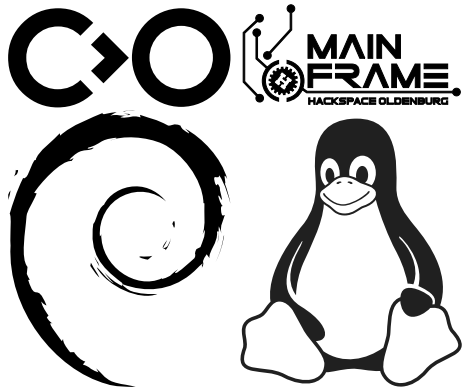


The power-supply subsystem

- batteries / fuel gauges
- chargers
- (board level poweroff/reset)
- Originally written and maintained by Anton Vorontsov (2007-2014)
- Temporarily maintained by Dmitry Eremin-Solenikov (2014)

Created by Blink@design from the Noun Project

Created by Jenie Tomboc from the Noun Project

Userspace Interface

```
root@localhost# ls /sys/class/power_supply/
AC  BAT0  BAT1
root@localhost# ls /sys/class/power_supply/BAT0
alarm                     energy_full_design  status
capacity                  energy_now          subsystem
capacity_level            manufacturer        technology
charge_start_threshold    model_name          type
charge_stop_threshold     power               uevent
cycle_count               power_now           voltage_min_design
...
root@localhost# cat /sys/class/power_supply/BAT0/capacity
65
```

Userspace Interface

```
root@localhost# udevadm info /sys/class/power_supply/BAT0
E: POWER_SUPPLY_CAPACITY=79
E: POWER_SUPPLY_ENERGY_FULL=15200000
E: POWER_SUPPLY_ENERGY_FULL_DESIGN=23200000
E: POWER_SUPPLY_ENERGY_NOW=12010000
E: POWER_SUPPLY_POWER_NOW=5890000
E: POWER_SUPPLY_STATUS=Discharging
E: POWER_SUPPLY_VOLTAGE_MIN_DESIGN=11100000
E: POWER_SUPPLY_VOLTAGE_NOW=11688000
...
```

Userspace Interface

- one power-supply device = one physical device
- All values are in uV, uA, uAh, uW, uWh, ...
- capacity can be exposed as
  - ENERGY_* - uWh
  - CHARGE_* - uAh
  - CAPACITY - percent (from 0 - 100)
  - CAPACITY_LEVEL - critical, low, normal, high, full

Power Supply Types

- **Battery**
- UPS (no mainline user)
- **Mains**
- **USB**
- USB_DCP, USB_CDP, USB_ACA, USB_TYPE_C, ... (deprecated)

Smart Batteries

- power-supply battery = smart battery
- smart battery = dumb battery + fuel gauge (+ static data)
- dumb battery = a bunch of battery cells
- fuel gauge = chip to measure battery status

Driver Construct

```c
// SPDX-License-Identifier: GPL-2.0+
#include <linux/platform_device.h>
#include <linux/power_supply.h>

static int my_battery_probe(struct platform_device *pdev) {
        return 0;
}
static struct platform_driver my_battery_driver = {
        .driver         = {
                .name                   = "my-battery",
        },
        .probe          = my_battery_probe,
};
module_platform_driver(my_battery_driver);
MODULE_LICENSE("GPL");
MODULE_AUTHOR("My Name <e-mail@address>");
MODULE_DESCRIPTION("My Battery Driver");
```

Device Tree

```
#ifdef CONFIG_OF
static const struct of_device_id my_battery_id_table[] = {
        { .compatible = "vendor,my-battery" },
        { }
};
MODULE_DEVICE_TABLE(of, my_battery_id_table);
#endif

static struct platform_driver my_battery_driver = {
        .driver         = {
                .of_match_table = of_match_ptr(my_battery_id_table),
                ...
        };
};
```

Device Tree

```
/ {
        some-controller {
                compatible = "vendor,my-controller";

                battery@42 {
                        reg = <0x42>;
                        compatible = "vendor,my-battery";
                        vendor,some-property;
                };
        };
};
```

Probe Function 1/2

```
static int my_battery_probe(struct platform_device *pdev)
{
        struct power_supply_desc *psy_desc;
        struct power_supply_config psy_cfg = {};
        struct my_battery_ddata *ddata;
        int err;

        ddata = devm_kzalloc(ddata->dev, sizeof(*ddata), GFP_KERNEL);
        if (!ddata)
                return -ENOMEM;
        psy_desc = devm_kzalloc(ddata->dev, sizeof(*psy_desc), GFP_KERNEL);
        if (!psy_desc)
                return -ENOMEM;

        psy_cfg.of_node = pdev->dev.of_node;
        psy_cfg.drv_data = ddata;
        ...
```

Probe Function 2/2

```
        ...
        psy_desc->name = "battery";
        psy_desc->type = POWER_SUPPLY_TYPE_BATTERY;
        psy_desc->properties = my_battery_props;
        psy_desc->num_properties = ARRAY_SIZE(my_battery_props);
        psy_desc->get_property = my_battery_get_property;

        ddata->psy = devm_power_supply_register(&pdev->dev, psy_desc, &psy_cfg);
        err = PTR_ERR_OR_ZERO(ddata->psy);
        if (err) {
                dev_err(ddata->dev, "failed to register power supply\n");
                return err;
        }

        return 0;
}
```

Power Supply property declaration

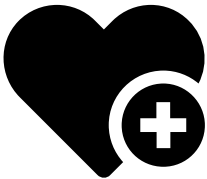
```
static enum power_supply_property my_battery_props[] = {
        POWER_SUPPLY_PROP_STATUS,
        POWER_SUPPLY_PROP_HEALTH,
        POWER_SUPPLY_PROP_TECHNOLOGY,
        POWER_SUPPLY_PROP_VOLTAGE_NOW,
        POWER_SUPPLY_PROP_CURRENT_NOW,
        POWER_SUPPLY_PROP_CAPACITY,
        POWER_SUPPLY_PROP_TEMP,
};
```

Power Supply property getter

```
static int my_battery_get_property(struct power_supply *psy, enum power_supply_property psp,
                                   union power_supply_propval *val)
{
        struct my_battery_ddata *ddata = power_supply_get_drvdata(psy);

        switch (psp) {
                case POWER_SUPPLY_PROP_STATUS: ... return 0;
                case POWER_SUPPLY_PROP_HEALTH: ... return 0;
                case POWER_SUPPLY_PROP_TECHNOLOGY: ... return 0;
                case POWER_SUPPLY_PROP_VOLTAGE_NOW: ... return 0;
                case POWER_SUPPLY_PROP_CURRENT_NOW: ... return 0;
                case POWER_SUPPLY_PROP_CAPACITY: ... return 0;
                case POWER_SUPPLY_PROP_TEMP: ... return 0;
                default: return -EINVAL;
        }
}
```

Power Supply property getter - HEALTH



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from the Noun Project

```
case POWER_SUPPLY_PROP_HEALTH:
        int status;
        ret = regmap_read(ddata->regmap, MY_BATTERY_REG_STATUS, &status);
        if (ret)
                return ret;
        val->intval = POWER_SUPPLY_HEALTH_GOOD;
        if (status & MY_BATTERY_STATUS_COLD)
                val->intval = POWER_SUPPLY_HEALTH_COLD;
        if (status & MY_BATTERY_STATUS_VOLTAGE)
                val->intval = POWER_SUPPLY_HEALTH_OVERVOLTAGE;
        if (status & MY_BATTERY_STATUS_HOT)
                val->intval = POWER_SUPPLY_HEALTH_OVERHEAT;
        return 0;
```

Power Supply property getter - VOLTAGE

```
case POWER_SUPPLY_PROP_VOLTAGE_NOW:
        int voltage;
        ret = regmap_read(ddata->regmap, MY_BATTERY_REG_VOLT, &voltage);
        if (ret)
                return ret;
        val->intval = mV * 1000; /* mV -> uV */
        return 0;
```

Created by Anusha Narvekar from the Noun Project

Power Supply property setter 1/2

```
static int my_battery_prop_is_writable(struct power_supply *psy,
                                       enum power_supply_property psp)
{
        switch (psp) {
                case POWER_SUPPLY_PROP_TEMP_ALERT_MIN:
                case POWER_SUPPLY_PROP_TEMP_ALERT_MAX:
                        return 1;
                default:
                        return 0;
        }
}

static int my_battery_probe(struct platform_device *pdev) {
        ...
        psy_desc->set_property = my_battery_set_property;
        psy_desc->property_is_writeable = my_battery_prop_is_writable;
        ...
}
```

Power Supply property setter 2/2

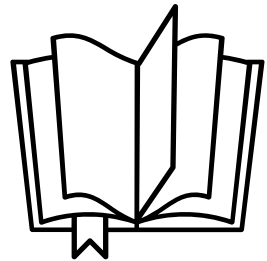
```
static int my_battery_set_property(struct power_supply *psy,
                                   enum power_supply_property psp,
                                   const union power_supply_propval *val)
{
        struct my_battery_ddata *ddata = power_supply_get_drvdata(psy);

        switch (psp) {
                case POWER_SUPPLY_PROP_TEMP_ALERT_MIN:
                        return regmap_write(ddata->regmap, MY_BATTERY_REG_ALARM_MIN, val->intval);
                case POWER_SUPPLY_PROP_TEMP_ALERT_MAX:
                        return regmap_write(ddata->regmap, MY_BATTERY_REG_ALARM_MAX, val->intval);
                default:
                        return -EINVAL;
        }
}
```

Power Supply - DONE

- ☑ Basic Driver construct
- ☑ DT initialization
- ☑ Driver Probe function
- ☑ Power Supply registration
- ☑ Get Property function
- ☑ Set Property function

power-supply documentation

- **Documentation/power/power_supply_class.txt**
- power-supply sysfs properties are now properly documented (Kudos to Adam Thomson)
- **Documentation/ABI/testing/sysfs-class-power**



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Power Supply - Custom sysfs attributes 1/2

- Always check if there is a generic attribute first
- Don't call `sysfs_create_*()`
  - It's racy!
  - Udev will not properly pick up the added attributes
- New feature arriving shortly (expected to arrive in 4.21)

Created by ProSymbols

Power Supply - Custom sysfs attributes 2/2

```
static ssize_t custom_attribute_show(struct device *dev, struct device_attribute *attr,
                                     char *buf) {
        return -EINVAL;
}
static DEVICE_ATTR_RO(custom_attribute);

static struct attribute *my_battery_sysfs_attrs[] = {
        &dev_attr_custom_attribute.attr,
        NULL
};
ATTRIBUTE_GROUPS(my_battery_sysfs);

struct power_supply_config psy_cfg = {
        ...
        .attr_grp = my_battery_sysfs_groups, /* power supply core will (de)register this */
};

devm_power_supply_register(dev, my_battery_desc, &psy_cfg);
```

Power Supply - Supply Chain 1/2

Documentation/devicetree/bindings/power/supply/power_supply.txt

```
usb_charger: power@1 {
        compatible = "vendor,usb-charger";
        ...
};
ac_charger: power@2 {
        compatible = "vendor,ac-charger";
        ...
};

battery@3 {
        compatible = "vendor,battery";
        power-supplies = <&usb_charger>, <&ac_charger>;
        ...
};
```

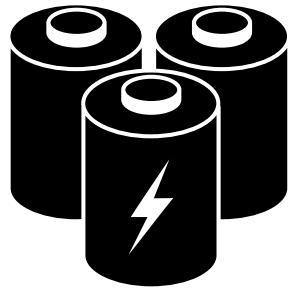
Power Supply - Supply Chain 2/2

```
static void my_battery_ext_pwr_changed(struct power_supply *psy)
{
        struct my_battery_ddata *ddata = power_supply_get_drvdata(psy);
        /* inform userspace, that battery status changed */
        power_supply_changed(psy);
}

static int my_battery_probe(struct platform_device *pdev) {
        struct power_supply_config psy_cfg = {
                .of_node = pdev->dev.of_node, /* provide DT info to power-supply core */
                ...
        };
        ...
        psy_desc->external_power_changed = my_battery_ext_pwr_changed;
        ...
        devm_power_supply_register(&pdev->dev, psy_desc, &psy_cfg);
}
```

Battery Info: power_supply_battery_info

- structure to describe battery characteristics
  - max. capacity
  - max. charge current
  - min/max. voltage
  - min/max. temperature
  - internal resistance
  - **WIP:** OCV to percentage table
- core provides function to acquire this information from DT
- consumed by fuel-gauge or charger
- Authored by Liam Breck



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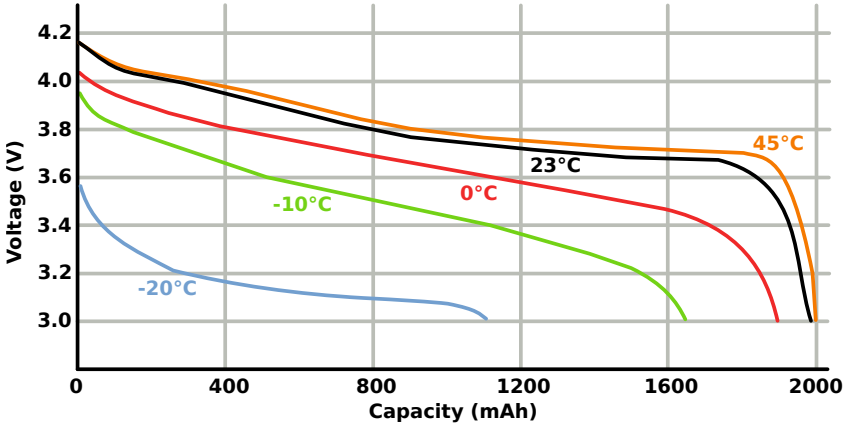
Battery Info

```c
/* structure to hold battery characteristics */
struct power_supply_battery_info info = {};

/* read dumb battery characteristics from DT/ACPI/... */
if (power_supply_get_battery_info(psy, &info) < 0)
        return -EINVAL;

if (info.energy_full_design_uwh == -EINVAL)
        return -EINVAL;
```

Battery Info: Discharge Curves



New 'usb_type' property

Old	New

$ cat .../BAT0/type
USB_CDP
	$ cat .../BAT0/type
	USB
	$ cat .../BAT0/usb_type
	DCP [CDP] ACA

- **type** property is supposed to be static and is read-only
- **usb_type** displays all supported modes
- **usb_type** marks current mode with square brackets
- **usb_type** may allow write access
- not all drivers have been converted (gpio-charger, isp1704, max14656)

New 'usb_type' property

```
static enum power_supply_usb_type my_charger_usb_types[] = {
        POWER_SUPPLY_USB_TYPE_UNKNOWN,
        POWER_SUPPLY_USB_TYPE_SDP,
        POWER_SUPPLY_USB_TYPE_DCP,
        POWER_SUPPLY_USB_TYPE_CDP
};
static enum power_supply_property my_charger_props[] = {
        ..., POWER_SUPPLY_PROP_USB_TYPE, ...
};
static int my_charger_probe(struct platform_device *pd) {
        ...
        psy_desc->properties = my_charger_props;
        psy_desc->num_properties = ARRAY_SIZE(my_charger_props);
        psy_desc->usb_types = my_charger_usb_types;
        psy_desc->num_usb_types = ARRAY_SIZE(my_charger_usb_types);
        ...
        return devm_power_supply_register(&pd->dev, psy_desc, &psy_cfg);
}
```

Shortcoming: Battery with multiple fuel gauges

- Each fuel-gauge driver stands for a smart battery
- Sometimes hardware has has two ways to measure battery properties
- This cannot be described with the power-supply subsystem at the moment

Shortcoming: Charger Manager

- Some embedded system require tight monitoring of charging process
- On x86 this is usually done via ACPI/embedded controller
- There is a charger-manager driver from Samsung doing this
- Proper support should exist in the core

Thanks!

Q & A