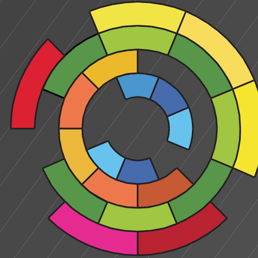

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ESC 2012: Rationalizing The Platform Perimeter

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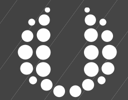


esc android NEW blackhat NEW designmed LEDs multicore sensors NEW

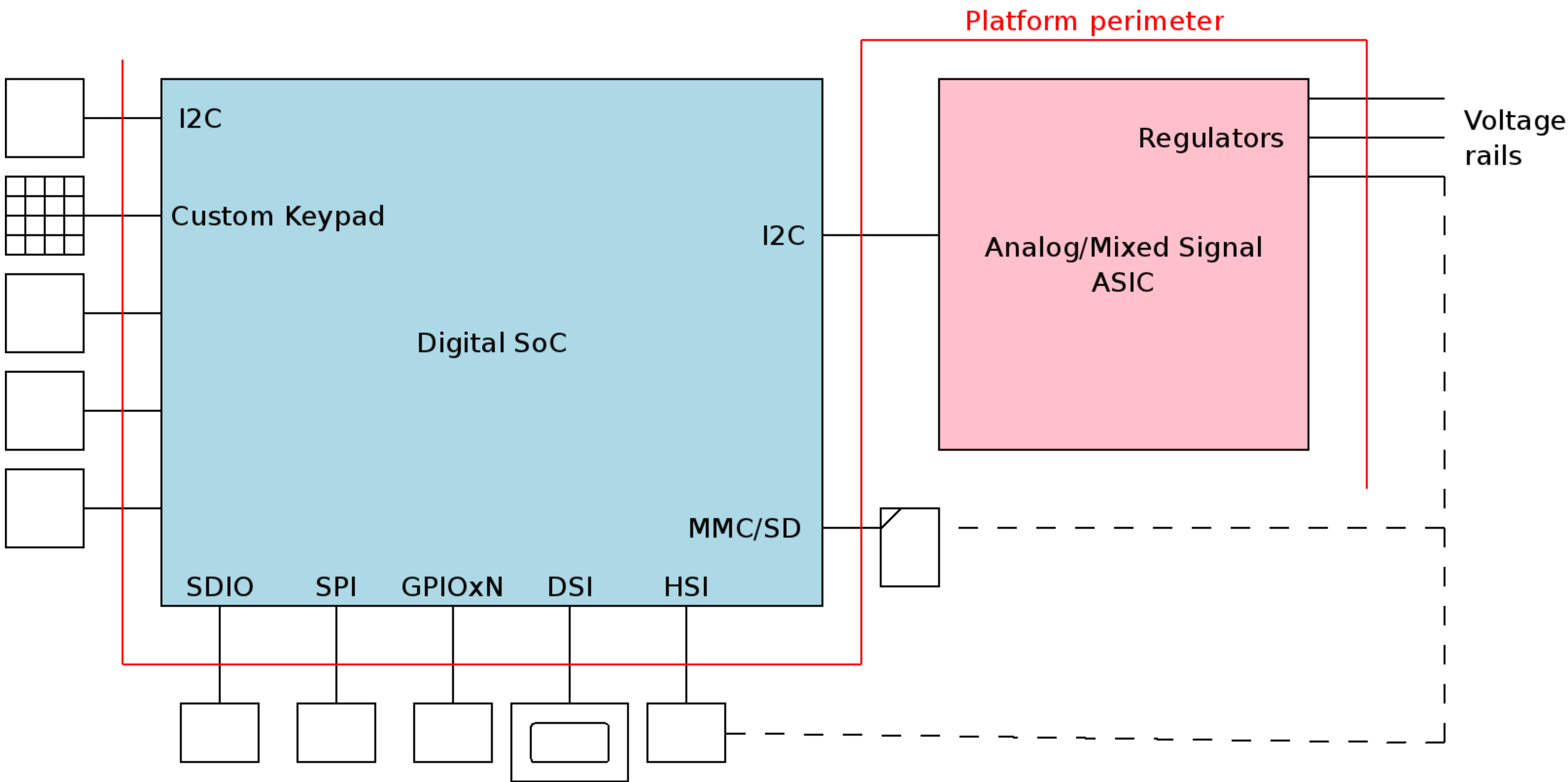
Background

Worked for some years with people trying to make the best use of the Linux kernel

- Noticed a lot of discrepancies between model and reality, long lead time from initiatives in the community to trickle down to embedded vendors
- Created the pin control subsystem in the Linux kernel to complement GPIO
- So I want to take this opportunity to try to present the state of relevant subsystems in the Linux kernel when working with the platform perimeter – what has been done so far and what is coming next
- The kernel changes relevant to *users* of SoC:s as opposed to the *producers* manufacturing the silicon
- See it as a ”perimeter report” as compared to Jon Corbets ”kernel reports” given at regular intervals about the state of the kernel at large

Recap: Linux device model

- Devices in Linux are defined by struct device, which may be subclassed by being a .dev entry of a sub-class device such as struct i2c_device
- Devices are usually registered to a bus
- Push to get rid of “class” and “type” device containers
- Introduction of reference-counting “power domain” concept in drivers/base/power/domain.c
- Push to stop using any statically declared struct device or derivates (struct platform_device, struct amba_device)
- Push to use Device Tree for registering all devices rather than board files – especially for the overpopulated ARM arch tree
- Push to use devm_* prefixed allocators etc to propely reference count and free especially memory allocated by device drivers
- Push to try to solve probe order problems currently often solved by pushing devices to different initlevels by using deferred probe which is basically a “probe me again, later” mechanism that will iterate the probe until dependencies are met


Platform perimeter
I2C
Custom Keypad
I2C
Digital SoC
MMC/SD
SDIO
SPI
GPIOxN
DSI
HSI
Regulators
Analog/Mixed Signal
ASIC
Voltage
rails

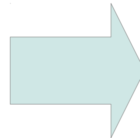
Device Tree Push (part 1)

- When the arch/arm/* tree was small, there were a few machines supported, mainly the RISC PC and then the StrongARM machines
- Then a lot of machines appeared and code was grouped into mach-foo/* directories with plat-foo/* directories to consolidate machine families
- Then things got out of hand:
  - No proper review of code going to machines
  - No active push to consolidate and refactor code across machines
  - All were "necessarily different" and thinking in their own silo
  - Merge conflicts and churn in the tree upsets Torvalds
- Quick fix: strip down defconfigs to the bare minimum deleting 194000 LOC
- ARM subarchitecture maintainers get together and discuss the problem
- One part of the problem is the "board files" – mainly static defines of the platform devices and their configuration

Device Tree Push (part 2)

- Device Tree presented as part of the solution – if we can get the data out of the kernel, the complexity can be reduced and/or externalized
- This should be easy – because experience shows it was easy for Power PC
- Strategy:
  - New platforms: only allow Device Tree probing
  - Legacy platforms: create new board files with the suffix -dt, move everything over then eventually delete the old board files
- Not as easy as it seems – Power PC was taken as model, but the PPC business was pretty closed and the producers had control over the software implementation process for their devices
- ARM was more chaotic and less keen on software standardization, also lack of volunteers and assignees to do the transition hampered progress
- So developers are still struggling with this
- However now it is happening due to the ARM SoC tree gatekeepers strong push and the backing of Linaro behind the Device Tree push
- Rely on Device Tree on a per-platform basis, not “one size fits all” for now

```
/* mach-foo/board-foo.c */

unsigned int mmc_status(struct device *dev)
{
        return !!readl(FOO_MMC_DETECT_REGISTER);
}

static struct mmci_platform_data mmc_plat_data = {
        .ocr_mask       = MMC_VDD_32_33|MMC_VDD_33_34,
        .status         = mmc_status,
        .gpio_wp        = -1,
        .gpio_cd        = -1,
};

static struct amba_device uart_device = {
        .res = {
                .start = 0x1000,
                .end   = 0x1000 + SZ_4K - 1,
                .flags = IORESOURCE_MEM,
        },
        .irq = { 1 },

};

static struct amba_device mmc_device = {
        .dev = {
                .platform_data = &mmc_plat_data,
        },
        .res = {
                .start = 0x2000,
                .end   = 0x2000 + SZ_4K - 1,
                .flags = IORESOURCE_MEM,
        },
        .irq = { 2, 3 },

};

static struct amba_device *amba_devs[] __initdata = {
        &uart_device,
        &mmc_device,
};

static void __init foo_init(void)
{
        int i;

        for (i = 0; i < ARRAY_SIZE(amba_devs); i++) {
                struct amba_device *d = amba_devs[i];
                amba_device_register(d, &iomem_resource);
        }
}

MACHINE_START(FOO, "Foo Machine")
        ...
        .init_machine   = foo_init,
MACHINE_END
```



```
/* mach-foo/board-foo-dt.c */

unsigned int mmc_status(struct device *dev)
{
        return !!readl(FOO_MMC_DETECT_REGISTER);
}

static struct mmci_platform_data mmc_plat_data = {
        .ocr_mask       = MMC_VDD_32_33|MMC_VDD_33_34,
        .status         = mmc_status,
        .gpio_wp        = -1,
        .gpio_cd        = -1,
};

struct of_dev_auxdata foo_auxdata_lookup[] __initdata = {
        OF_DEV_AUXDATA("arm,primecell", 0x2000, "mmci",
                 &mmc_plat_data),
};

static void __init foo_dt_init(void)
{
        of_platform_populate(NULL, of_default_bus_match_table,
                             foo_auxdata_lookup, NULL);
}

static const char *foo_dt_match[] __initconst = {
        "arm,foo",
        NULL,
};

DT_MACHINE_START(FOO, "Foo Machine")
        ...
        .init_machine   = foo_dt_init,
        .dt_compat      = foo_dt_match,
MACHINE_END
```

The below is supplied in binary compiled form to the kernel from the boot loader or attached to the kernel image:

```
/include/ "foo.dts"

/ {
        model = "Foo";
        compatible = "arm,foo";

        amba {
                uart@1000 {
                        compatible = "arm,primecell";
                        reg = <0x1000 0x1000>;
                        interrupts = <1>;
                };

                mmc@2000 {
                        compatible = "arm,primecell";
                        reg = <0x2000 0x1000>;
                        interrupts = <2, 3>;
                };
        };
};
```

Device Tree Push (part 3)

- SoC vendor should provide the basic SoC Device Tree in a file named "foo-soc.dtsi, then board files are created named "board-foo.dts"
- Example:
  - arch/arm/boot/dts/tegra20.dtsi – defines a SoC
  - arch/arm/boot/dts/tegra-ventana.dts – defines a specific board
- Through the .dts file you will one day be able to configure the entire platform perimeter – if everything goes well
- For example the SoC .dtsi file defines all the I2C buses, whereas your foo-board.dts file define all the devices that sit on the I2C bus
- You will still have to write drivers for all devices and compile them into your kernel or as modules ...
- Device Tree does not remove hard work, all it does is help a little bit with structuring the board files and keeping their configuration outside of the Linux kernel

I2C [drivers/i2c/*]

- Very mature subsystem, mainly seeing maintenance of bus drivers
- Regmap support in drivers/base/regmap/regmap-i2c.c (more on regmap soon!)
- Runtime PM
- All bus drivers needs to be augmented for Device Tree support
- Chip drivers removed from the subsystem and into respective driver subsystem – only core I2C business live here now (completed by Wolfram Sang in 2010)

SPI [drivers/spi/*]

- Quite mature subsystem, missing common infrastructure
- Proposed patch to create a central message queue mechanism
- Regmap support in drivers/base/regmap/regmap-spi.c
  (more on regmap soon!)
- Runtime PM
- All bus drivers needs to be augmented for Device Tree support

MFD [drivers/mfd/*]

- Multifunction Devices loosely defined as central child device spawning and arbitration hub
- Natural nexus for Mixed Signal circuits such as PMICs exposing various analog electronic controls as an automaton
- Many of these devices are I2C or SPI devices or both
- The Mixed Signal circuits then spawn devices in regulator, ALSA SoC, LED, backlight, PWM, GPIO ...

Regmap [drivers/base/regmap/*]

- ALSA System-on-Chip (ASOC) engineers noted that their register access and caching mechanism was generally useful
- In theory suitable for any register range not memory-mapped but accessed by other means, primarily I2C and SPI
- Handles marshalling register accesses to say 16 or 32 bit registers using consecutive 8bit writes/reads on an I2C bus
- Handles registering expected default values to a large register map at boot so these do not need to be read up from hardware at all
- Handles caching of registers declared non-volatile
- Writes write through and updates the cache
- Reads-through on volatile registers
- Cache is stored in a rbtree
- End result is a speed boost on anything register-based that is handled over a slow peripheral bus that can benefit from caching and simplification and centralization of code for marshalling register access

GPIO [drivers/gpio/*]

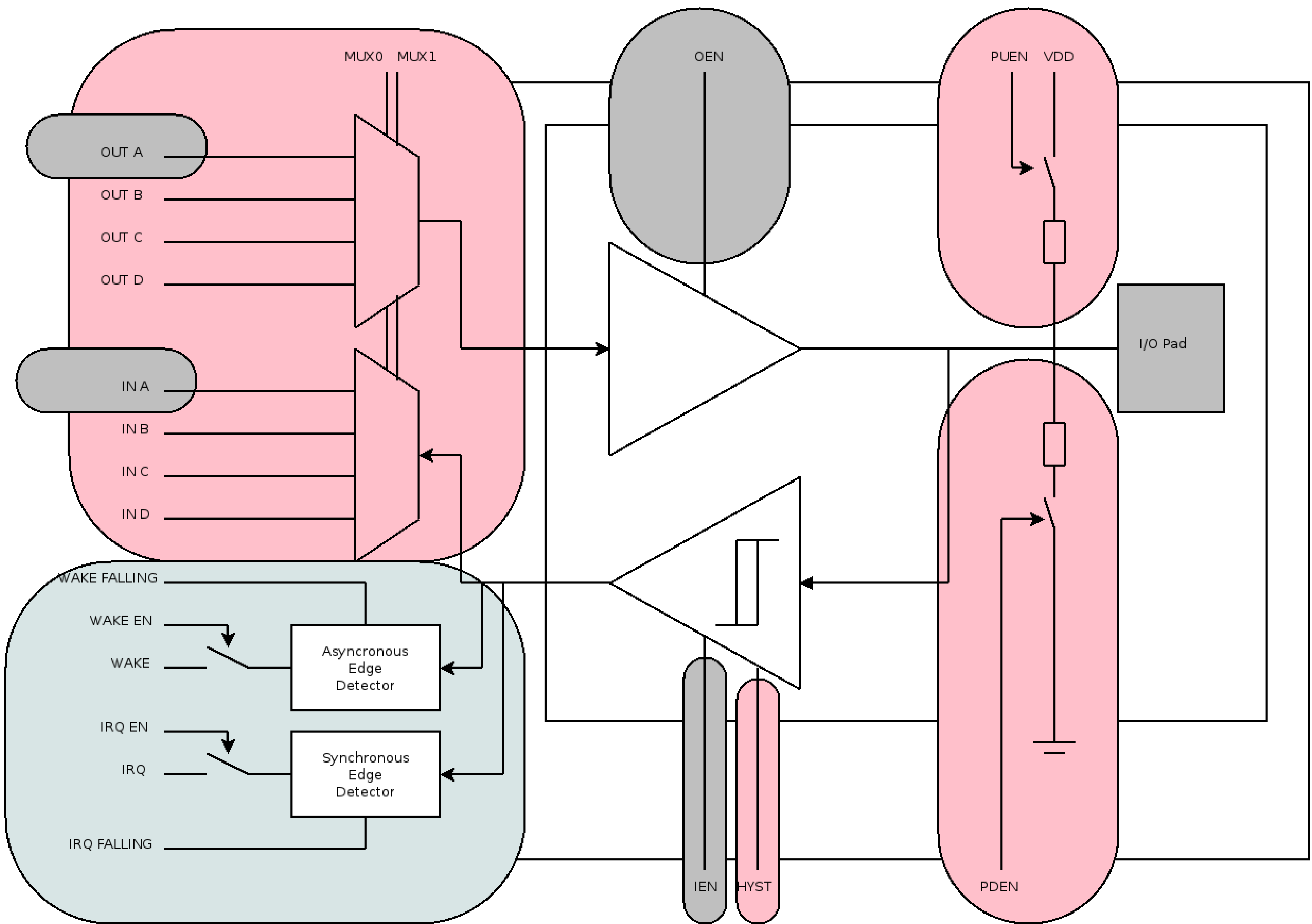
- Big push to move any GPIO drivers out of the arch/arm/* hierarchy and down to the GPIO subsystem, some may remain
- We want to remove generic GPIO once designed for performance bottlenecks and have all drivers use gpiolib
- ARM users split in simple cases (just gpiolib) and "__ARM_GPIOLIB_COMPLEX" which provide custom access macros for example to be used early. Very limited number of users.
- One goal is to get rid of <mach/gpio.h> to compile a multi-platform kernel
- Generic Device Tree bindings in place for GPIO keys, leds
- Everything else will need Device Tree bindings

Things TODO on a longer term:

- We want to get rid of the global GPIO numberspace
- We want to rewrite the questionable userspace interface in sysfs and replace with /dev/gpio0 etc for the gpio_chip:s

Pin Control [drivers/pinctrl/*]

- New subsystem for handling pin multiplexing, pin configuration (push, biasing, drive mode, schmitt-trigger etc) and anything else that is not already handled by GPIOlib or struct irq_chip
- Has caused endless pain for system designers using off-the-shelf SoC:s over the years
- I just had enough of custom pin configuration and created a new subsystem for pin control
- Illustration on following page on what is pin control and what is GPIO or irq_chip for a certain IO Pad
- Migrated a number of platforms to use this instead of custom pin control implementations
- Device driver interface similar to regulators or clocks, drivers can get handles to pins (both individual pins and groups of pins) and put these into different states at runtime
- Working on generic pin states and Device Tree bindings as we speak



MUX0
MUX1
OEN
PUEN
VDD
OUT A
OUT B
OUT C
OUT D
IN A
IN B
IN C
IN D
I/O Pad
WAKE FALLING
WAKE EN
WAKE
Asyncronous
Edge
Detector
IRQ EN
IRQ
Synchronous
Edge
Detector
IRQ FALLING
IEN
HYST
PDEN

HSI [will be drivers/hsi/*]

- Reads out High Speed Synchronous Serial Interface
- New subsystem in the works
- Used for connecting especially high-speed modems to SoC:s
- Nokias Carlos Chinea has created a subsystem
- Proposed for inclusion into Linux v3.3 but was not pulled in

Regulators [drivers/regulator/*]

- Well-established and mature subsystem
- Device drivers increasingly using the regulators to get their voltages
- Deep integration into the MMC/SD subsystem
- Preferred *design pattern* for device drivers: if your device has any kind of voltage supplies, retrieve them with regulator_get(dev, ”FOO”); and define a simple fixed-voltage regulator even if they happen to be wired to correct always-available supplies on your system. Further down the road someone will inevitably connect the same input to a software-controlled regulator
- Finalized Device Tree bindings for core regulator descriptors

MMC/SD/SDIO [drivers/mmc/*]

- Well-established and maturing as we speak
- Several large patchsets for supporting new eMMC and SD specs progressing in an incremental manner – if you need any one particular feature you need to worry else business as usual
- Numerous SDIO fixes the last kernel releases to get e.g. WLAN adapters attached to SDIO to work properly with odd packet sizes
- Several host drivers may still have severe SDIO problems – beware!
- All host drivers need to be augmented with Device Tree bindings, but that's not a perimeter problem!

Input subsystem [drivers/input/*]

- Well-established and mature subsystem
- External connectors moving out of the input subsystem and into the Android-derived "extcon" subsystem in drivers/extcon/* initiative driven by MyungJoo Ham from Samsung
- Extcon will be used for plug-in events of USB cables (i.e. for classless USB charging "chinese charger", audio-video-HDMI jacks
- Major embedded touchscreen vendors especially Synaptics increasingly dedicated to supporting Linux, also in the mainline kernel (maturation)
- GPIO keypads have Device Tree bindings, everything else especially anything custom needs new bindings

On the other side of the wire

- Industrial I/O (IIO) subsystem is gaining traction in staging, need to move into the drivers/* proper – especially crucial feature: timestamped measurements such as needed for industrial control but also for say augmented reality
- All drivers everywhere need to be augmented with Device Tree bindings

THANK YOU