深 入 探 究Linux的 设 备 树

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报名直播或者录播：
http://edu.csdn.net/huiyiCourse/detail/465

扫描二维码报名

麦当劳喜欢您来，喜欢您再来

扫描关注

Linuxer

设 备 树 的 终 极 目 的

https://www.kernel.org/doc/Documentation/devicetree/usage-model.txt

The “Open Firmware Device Tree”, or simply Device Tree (DT), is a data structure and language for describing hardware. More specifically, it is a description of hardware that is readable by an operating system so that the operating system doesn’t need to hard code details of the machine.

提供一种语言来解耦硬件配置信息

历史和现在

- ✓ 最早：

2005 PowerPC Linux

- ✓ 现在：

arm, microblaze, mips, powerpc, sparc, x86
Openrisc, c6x

X86: arch/x86/platform/ce4100 (intel凌动处理器)

Device trees everywhere

设备端：使用设备树之前

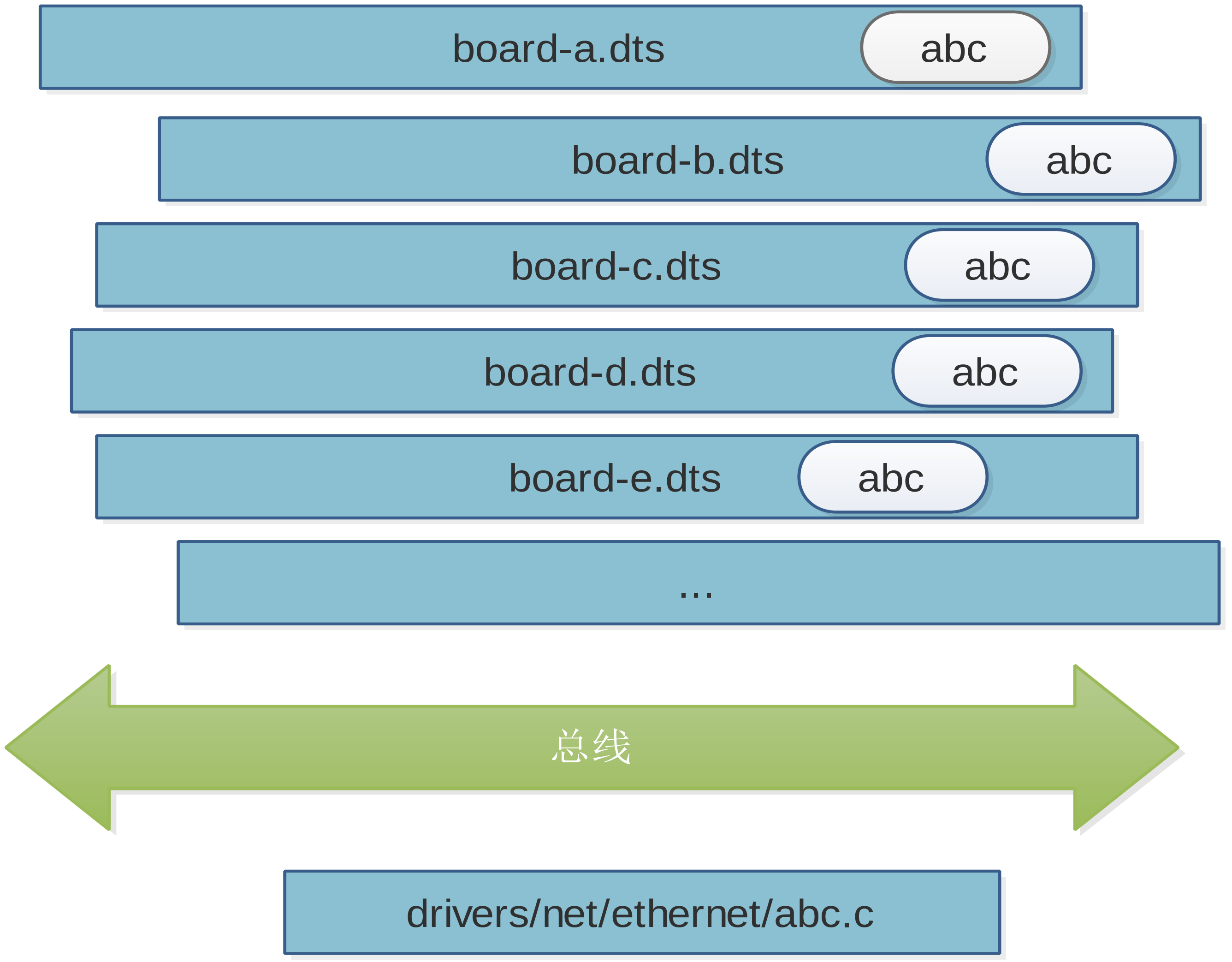
```
static struct resource dm9000_resource1[] = {
		{
			.start = 0x20100000,
			.end   = 0x20100000 + 1,
			.flags = IORESOURCE_MEM
		...
			.start = IRQ_PF15,
			.end   = IRQ_PF15,
			.flags = IORESOURCE_IRQ | IORESOURCE_IRQ_HIGHEDGE
		}
};

static struct platform_device dm9000_device1 = {
		.name           = "dm9000",
		.id             = 0,
		.num_resources  = ARRAY_SIZE(dm9000_resource1),
		.resource       = dm9000_resource1,
};

static struct platform_device *ip0x_devices[] __initdata = {
		&dm9000_device1,
		&dm9000_device2,
};

static int __init ip0x_init(void)
{
		platform_add_devices(ip0x_devices, ARRAY_SIZE(ip0x_devices));
}
```

设 备 端： 使 用 设 备 树 之 后

开机过程中执行的类似语句会帮忙从dts节点生成platform_device：
of_platform_populate(NULL, of_default_bus_match_table,
NULL, NULL);

```
eth: eth@4,c00000 {
        compatible = "davicom,dm9000";
        reg = <
            4 0x00c00000 0x2
            4 0x00c00002 0x2
        >;
        interrupt-parent = <&gpio2>;
        interrupts = <14 IRQ_TYPE_LEVEL_LOW>;
        ...
    };
```

设备在脚本，驱动在C里


board-a.dts
abc
board-b.dts
abc
board-c.dts
abc
board-d.dts
abc
board-e.dts
abc
...
总线
drivers/net/ethernet/abc.c

驱动端:代码几乎不变: drivers/xxx/

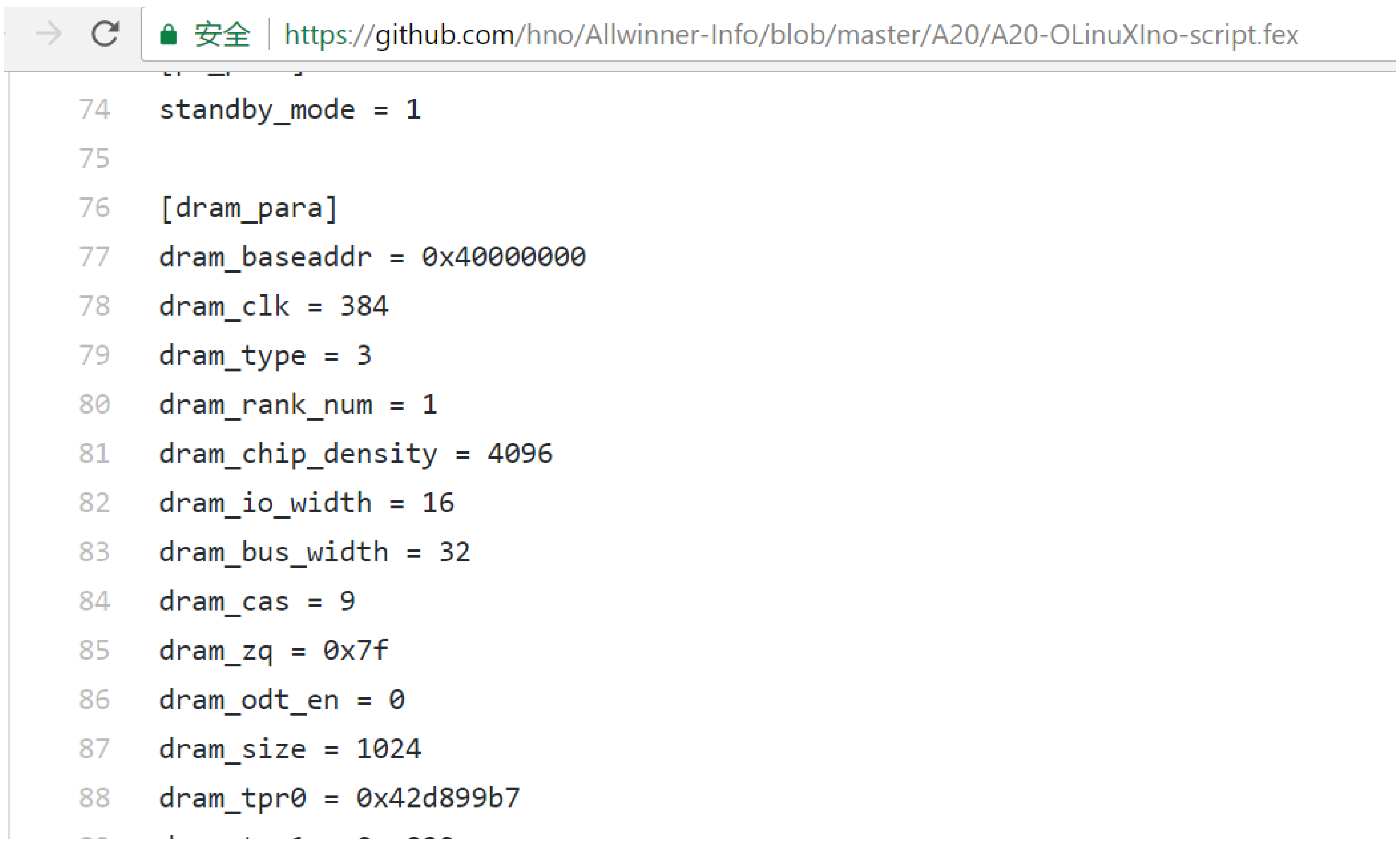
```
static int dm9000_probe(struct platform_device *pdev)
{
	...
	db->addr_res = platform_get_resource(pdev, IORESOURCE_MEM, 0);
	db->data_res = platform_get_resource(pdev, IORESOURCE_MEM, 1);
	db->irq_res  = platform_get_resource(pdev, IORESOURCE_IRQ, 0);
	...
}

static struct platform_driver dm9000_driver = {
	.driver = {
		.name    = "dm9000",
		.pm      = &dm9000_drv_pm_ops,
		.of_match_table = of_match_ptr(dm9000_of_matches),
	},
	.probe   = dm9000_probe,
	.remove  = dm9000_drv_remove,
};
```

ARM设备树支持的相关补丁

Gaah. Guys, this whole ARM thing is a f*cking pain in the ass.
Linus, 2011,
http://lkml.org/lkml/2011/3/17/492

- 2011-07-25 arm/dt: Add dtb make rule Rob Herring2-0/+13
- 2011-07-25 arm/dt: Add skeleton dtsi file Grant Likely1-0/+13
- 2011-07-25 arm/dt: Add dt machine definition Grant Likely1-0/+7
- 2011-05-23 arm/dt: probe for platforms via the device tree Grant Likely6-4/+135
- 2011-05-23 arm/dt: consolidate atags setup into setup_machine_atags Grant Likely2-29/+47
- 2011-05-11 arm/dt: Allow CONFIG_OF on ARM Grant Likely7-1/+92
- 2011-05-11 arm/dt: Make __vet_atags also accept a dtb image Grant Likely2-10/+22

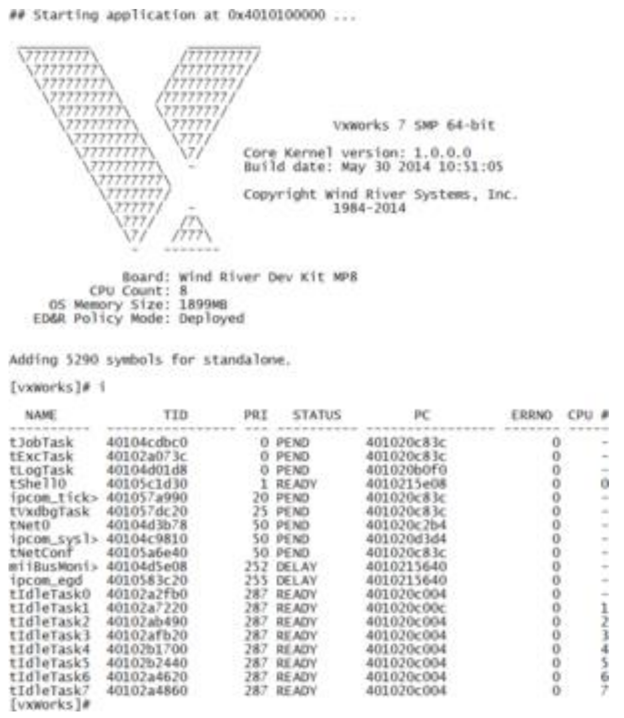
相 似 的 东 西-allwinner的fex


安全 https://github.com/hno/Allwinner-Info/blob/master/A20/A20-OLinuXIno-script.fex

```
standby_mode = 1

[dram_para]
dram_baseaddr = 0x40000000
dram_clk = 384
dram_type = 3
dram_rank_num = 1
dram_chip_density = 4096
dram_io_width = 16
dram_bus_width = 32
dram_cas = 9
dram_zq = 0x7f
dram_odt_en = 0
dram_size = 1024
dram_tpr0 = 0x42d899b7
```

支持设备树的OS和平台

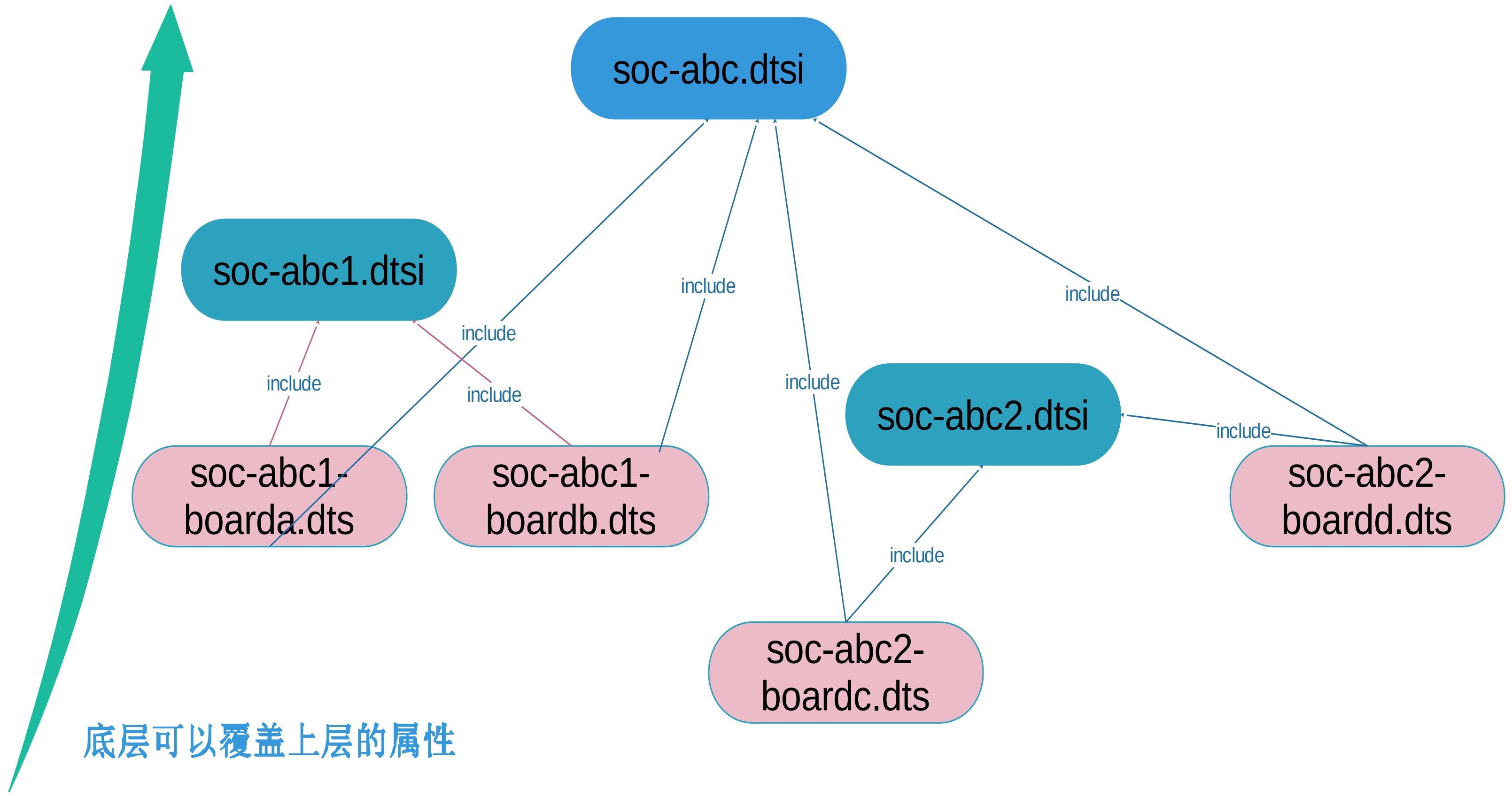
https://wiki.freebsd.org/FlattenedDeviceTree



```
## Starting application at 0x4010100000 ...

 _________            _________
 \77777777\          /77777777/
  \77777777\        /77777777/
   \77777777\      /77777777/
    \77777777\    /77777777/
     \77777777\   \7777777/
      \77777777\   \77777/         VxWorks 7 SMP 64-bit
       \77777777\   \777/
        \77777777\   \7/       Core Kernel version: 1.0.0.0
         \77777777\   -        Build date: May 30 2014 10:51:05
          \77777777\
           \7777777/           Copyright Wind River Systems, Inc.
            \77777/   -                    1984-2014
             \777/   /7\
              \7/   /777\
               -   -------

               Board: Wind River Dev Kit MP8
           CPU Count: 8
      OS Memory Size: 1899MB
    ED&R Policy Mode: Deployed

Adding 5290 symbols for standalone.

[vxWorks]# i

  NAME              TID          PRI   STATUS          PC           ERRNO  CPU #
----------  ---------------- --- ---------- ---------------- -------  -----
tJobTask     40104cdbc0         0 PEND       401020c83c               0      -
tExcTask     40102a073c         0 PEND       401020c83c               0      -
tLogTask     40104d01d8         0 PEND       401020b0f0               0      -
tShell0      40105c1d30         1 READY      4010215e08               0      0
ipcom_tick>  401057a990        20 PEND       401020c83c               0      -
tVxdbgTask   401057dc20        25 PEND       401020c83c               0      -
tNet0        40104d3b78        50 PEND       401020c2b4               0      -
ipcom_sysl>  40104c9810        50 PEND       401020d3d4               0      -
tNetConf     40105a6e40        50 PEND       401020c83c               0      -
miiBusMoni>  40104d5e08       252 DELAY      4010215640               0      -
ipcom_egd    4010583c20       255 DELAY      4010215640               0      -
tIdleTask0   40102a2fb0       287 READY      401020c004               0      -
tIdleTask1   40102a7220       287 READY      401020c00c               0      1
tIdleTask2   40102ab490       287 READY      401020c004               0      2
tIdleTask3   40102afb20       287 READY      401020c004               0      3
tIdleTask4   40102b1700       287 READY      401020c004               0      4
tIdleTask5   40102b2440       287 READY      401020c004               0      5
tIdleTask6   40102a4620       287 READY      401020c004               0      6
tIdleTask7   40102a4860       287 READY      401020c004               0      7
[vxWorks]#
```

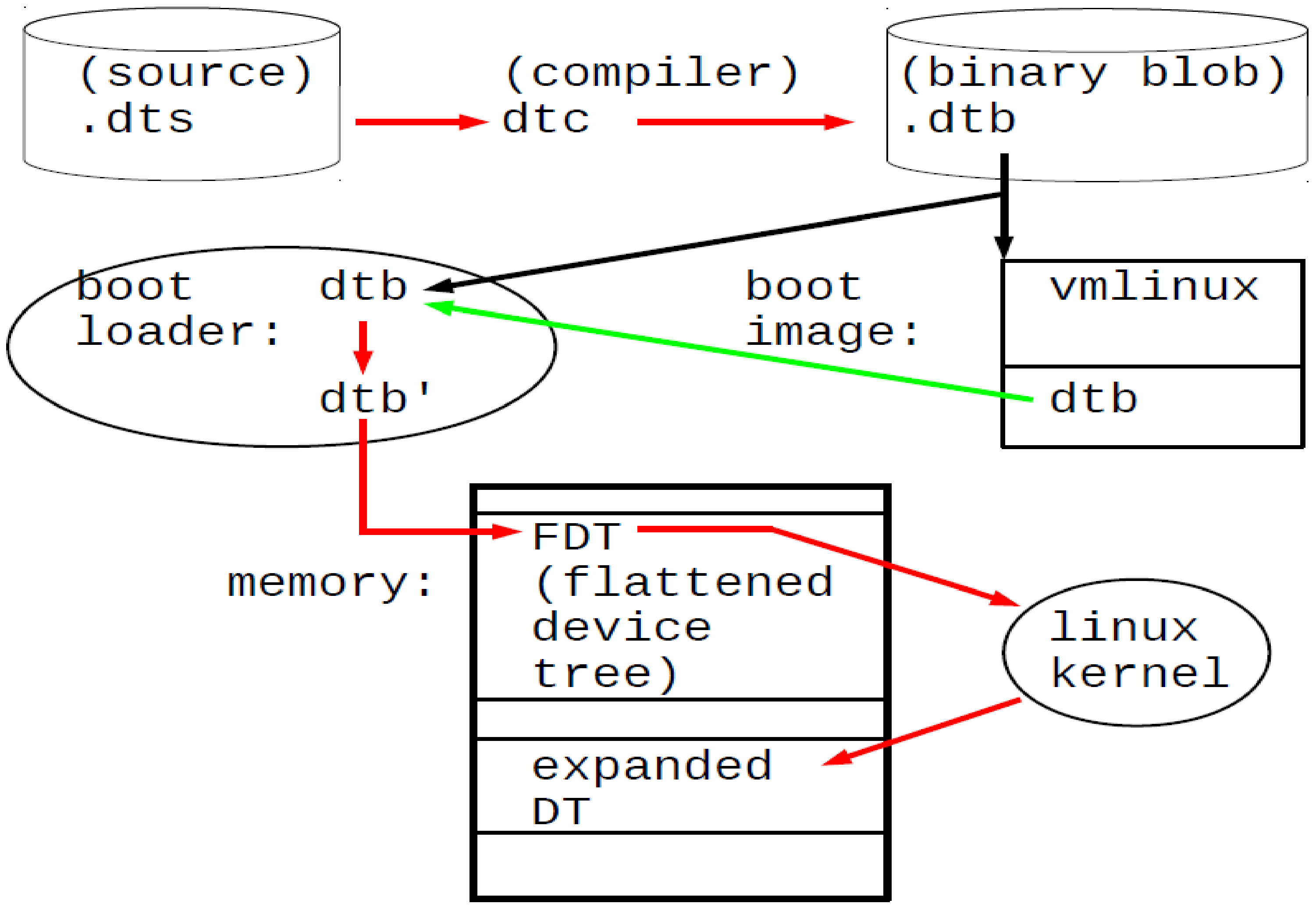
Das U-Boot –
 the Universal Boot Loader

dtsi和dts

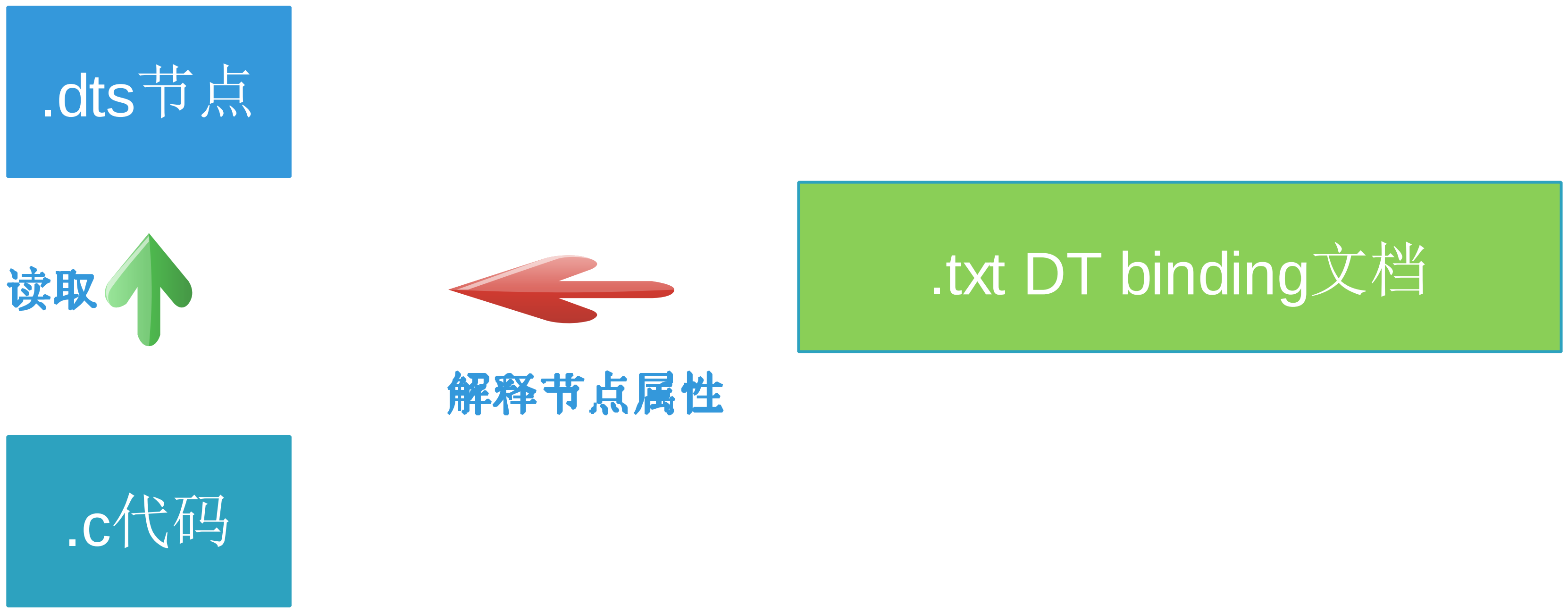


soc-abc.dtsi
soc-abc1.dtsi
soc-abc2.dtsi
soc-abc1-boarda.dts
soc-abc1-boardb.dts
soc-abc2-boardc.dts
soc-abc2-boardd.dts
include
底层可以覆盖上层的属性

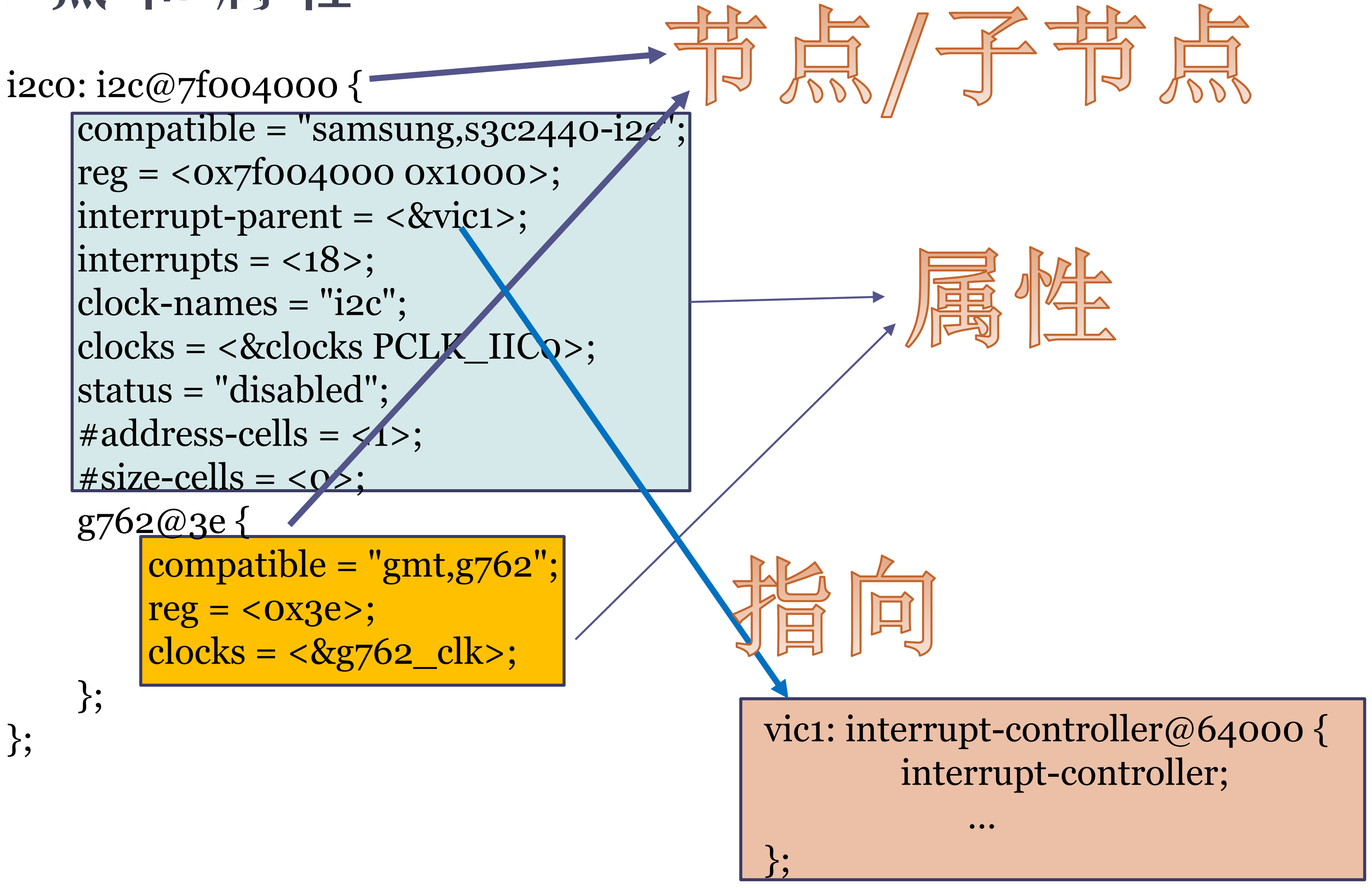
设备树的生命周期


(source)
.dts
(compiler)
dtc
(binary blob)
.dtb
boot loader:
dtb
dtb'
boot image:
vmlinux
dtb
memory:
FDT
(flattened device tree)
expanded DT
linux kernel

脚本、代码、文档



节点和属性



```
i2c0: i2c@7f004000 {
        compatible = "samsung,s3c2440-i2c";
        reg = <0x7f004000 0x1000>;
        interrupt-parent = <&vic1>;
        interrupts = <18>;
        clock-names = "i2c";
        clocks = <&clocks PCLK_IIC0>;
        status = "disabled";
        #address-cells = <1>;
        #size-cells = <0>;
        g762@3e {
                compatible = "gmt,g762";
                reg = <0x3e>;
                clocks = <&g762_clk>;

        };
};
```

```
vic1: interrupt-controller@64000 {
            interrupt-controller;
            ...
};
```

一个bool节点属性的来龙去脉

omap5-sbc-t54.dts

```
&mmc1 {
	...
	cd-inverted;
	wp-inverted;
	...
};
```

脚本

代码

drivers/mmc/core/host.c

```
cd_cap_invert = of_property_read_bool(np, "cd-inverted");
ro_cap_invert = of_property_read_bool(np, "wp-inverted");
```

文档

Documentation/devicetree/bindings/mmc/mmc.txt

```
- cd-inverted: when present, polarity on the CD line is inverted. See the note
  below for the case, when a GPIO is used for the CD line
- wp-inverted: when present, polarity on the WP line is inverted. See the note
  below for the case, when a GPIO is used for the WP line
```

一个u32数组节点属性的来龙去脉

tegra30.dtsi

```
arm,data-latency = <6 6 2>;
```

脚本

arch/arm/mm/cache-l2x0.c

```
of_property_read_u32_array(np, "arm,data-latency",
        data, ARRAY_SIZE(data));
```

代码

Documentation/devicetree/bindings/arm/l2cc.txt

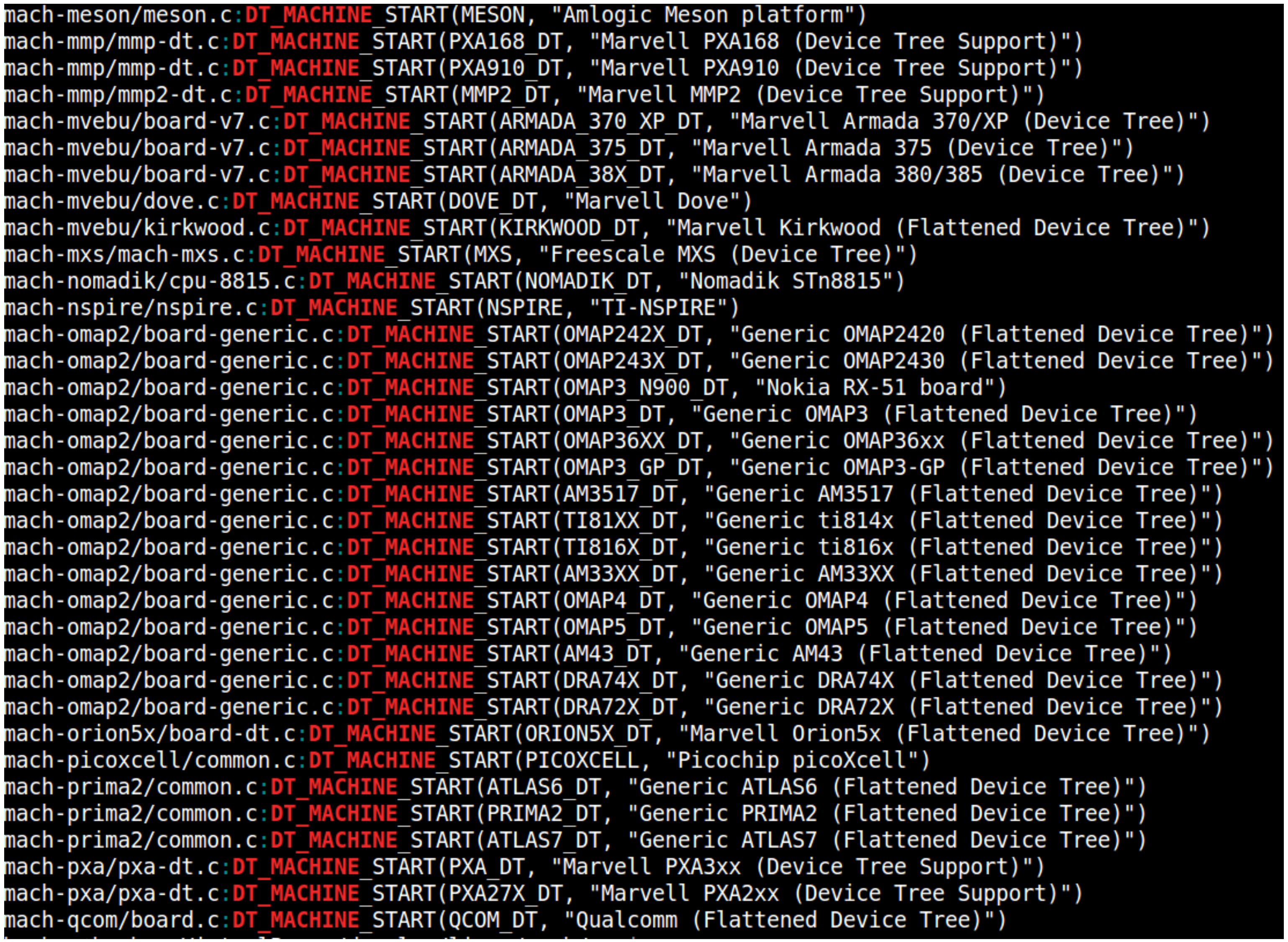
文档

- arm,data-latency : Cycles of latency for Data RAM accesses. Specifies 3 cells of read, write and setup latencies. Minimum valid values are 1. Controllers without setup latency control should use a value of 0.

设备树数据的三大作用

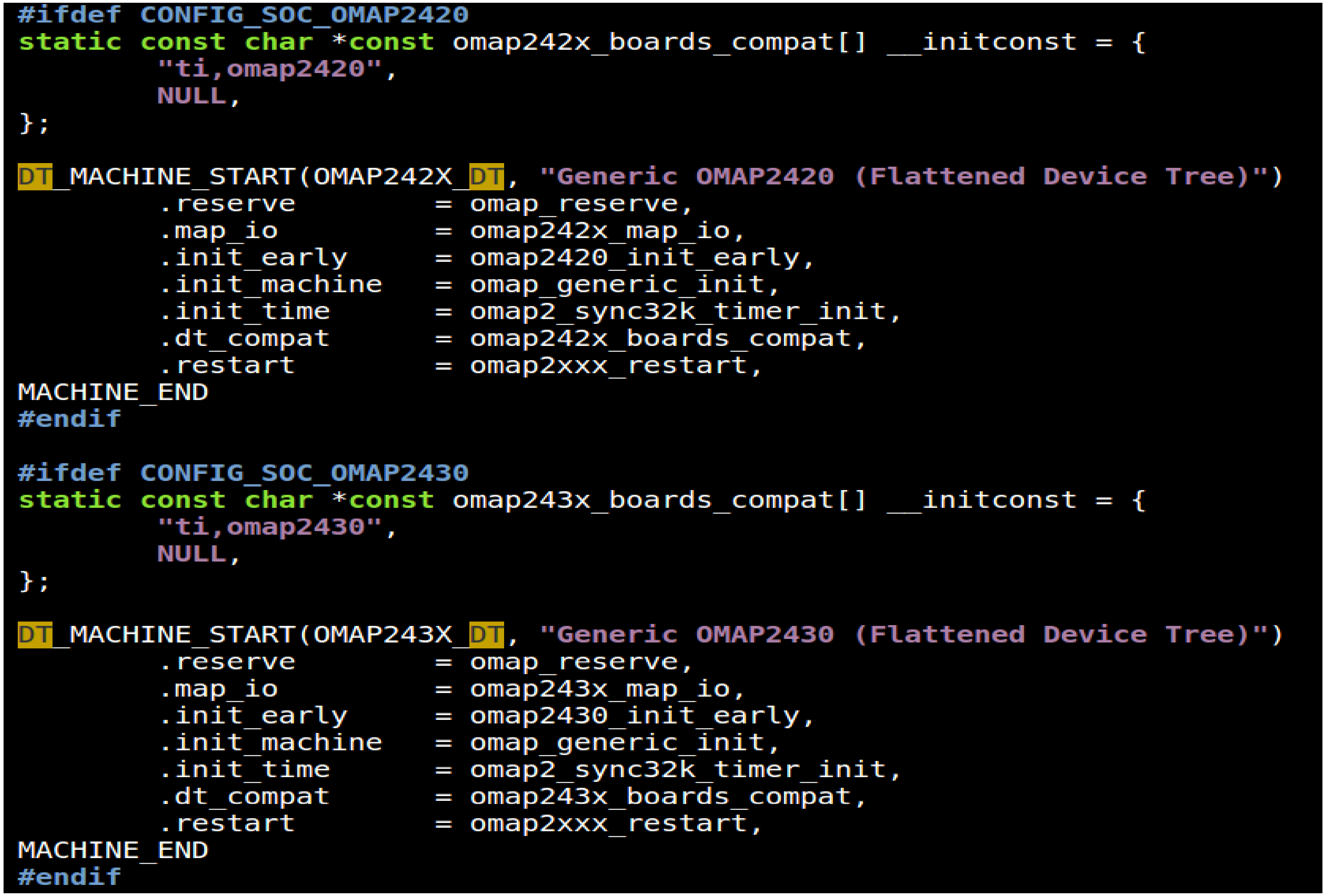
平台标识 platform identification	**用DT来标识特定的machine；root节点的compatible字段，匹配machine_desc的dt_compat 比如： compatible = "ti,omap3-beagleboard", "ti,omap3450", "ti,omap3";**
运行时配置 runtime configuration	chosen节点的属性 chosen { bootargs = "console=ttyS0,115200 loglevel=8"; initrd-start = <0xc8000000>; initrd-end = <0xc8200000>; };
设备信息集合 device population	serial@70006300 { compatible = "nvidia,tegra20-uart"; reg = <0x70006300 0x100>; interrupts = <122>; };

平台标识 – DT_MACHINE



```
mach-meson/meson.c:DT_MACHINE_START(MESON, "Amlogic Meson platform")
mach-mmp/mmp-dt.c:DT_MACHINE_START(PXA168_DT, "Marvell PXA168 (Device Tree Support)")
mach-mmp/mmp-dt.c:DT_MACHINE_START(PXA910_DT, "Marvell PXA910 (Device Tree Support)")
mach-mmp/mmp2-dt.c:DT_MACHINE_START(MMP2_DT, "Marvell MMP2 (Device Tree Support)")
mach-mvebu/board-v7.c:DT_MACHINE_START(ARMADA_370_XP_DT, "Marvell Armada 370/XP (Device Tree)")
mach-mvebu/board-v7.c:DT_MACHINE_START(ARMADA_375_DT, "Marvell Armada 375 (Device Tree)")
mach-mvebu/board-v7.c:DT_MACHINE_START(ARMADA_38X_DT, "Marvell Armada 380/385 (Device Tree)")
mach-mvebu/dove.c:DT_MACHINE_START(DOVE_DT, "Marvell Dove")
mach-mvebu/kirkwood.c:DT_MACHINE_START(KIRKWOOD_DT, "Marvell Kirkwood (Flattened Device Tree)")
mach-mxs/mach-mxs.c:DT_MACHINE_START(MXS, "Freescale MXS (Device Tree)")
mach-nomadik/cpu-8815.c:DT_MACHINE_START(NOMADIK_DT, "Nomadik STn8815")
mach-nspire/nspire.c:DT_MACHINE_START(NSPIRE, "TI-NSPIRE")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP242X_DT, "Generic OMAP2420 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP243X_DT, "Generic OMAP2430 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP3_N900_DT, "Nokia RX-51 board")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP3_DT, "Generic OMAP3 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP36XX_DT, "Generic OMAP36xx (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP3_GP_DT, "Generic OMAP3-GP (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(AM3517_DT, "Generic AM3517 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(TI81XX_DT, "Generic ti814x (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(TI816X_DT, "Generic ti816x (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(AM33XX_DT, "Generic AM33XX (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP4_DT, "Generic OMAP4 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(OMAP5_DT, "Generic OMAP5 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(AM43_DT, "Generic AM43 (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(DRA74X_DT, "Generic DRA74X (Flattened Device Tree)")
mach-omap2/board-generic.c:DT_MACHINE_START(DRA72X_DT, "Generic DRA72X (Flattened Device Tree)")
mach-orion5x/board-dt.c:DT_MACHINE_START(ORION5X_DT, "Marvell Orion5x (Flattened Device Tree)")
mach-picoxcell/common.c:DT_MACHINE_START(PICOXCELL, "Picochip picoXcell")
mach-prima2/common.c:DT_MACHINE_START(ATLAS6_DT, "Generic ATLAS6 (Flattened Device Tree)")
mach-prima2/common.c:DT_MACHINE_START(PRIMA2_DT, "Generic PRIMA2 (Flattened Device Tree)")
mach-prima2/common.c:DT_MACHINE_START(ATLAS7_DT, "Generic ATLAS7 (Flattened Device Tree)")
mach-pxa/pxa-dt.c:DT_MACHINE_START(PXA_DT, "Marvell PXA3xx (Device Tree Support)")
mach-pxa/pxa-dt.c:DT_MACHINE_START(PXA27X_DT, "Marvell PXA2xx (Device Tree Support)")
mach-qcom/board.c:DT_MACHINE_START(QCOM_DT, "Qualcomm (Flattened Device Tree)")
```

平台标识 – mach-omap2/board-generic.c

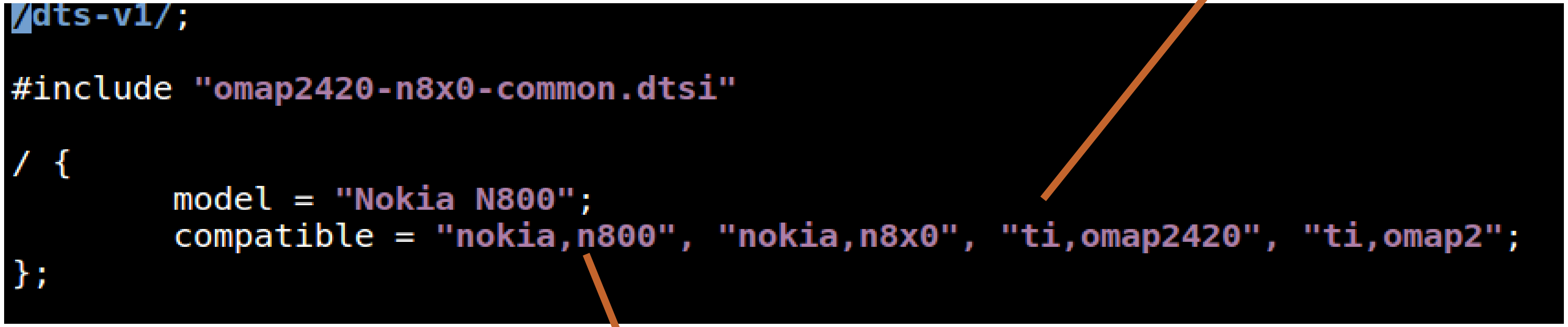


```
#ifdef CONFIG_SOC_OMAP2420
static const char *const omap242x_boards_compat[] __initconst = {
        "ti,omap2420",
        NULL,
};

DT_MACHINE_START(OMAP242X_DT, "Generic OMAP2420 (Flattened Device Tree)")
        .reserve        = omap_reserve,
        .map_io         = omap242x_map_io,
        .init_early     = omap2420_init_early,
        .init_machine   = omap_generic_init,
        .init_time      = omap2_sync32k_timer_init,
        .dt_compat      = omap242x_boards_compat,
        .restart        = omap2xxx_restart,
MACHINE_END
#endif

#ifdef CONFIG_SOC_OMAP2430
static const char *const omap243x_boards_compat[] __initconst = {
        "ti,omap2430",
        NULL,
};

DT_MACHINE_START(OMAP243X_DT, "Generic OMAP2430 (Flattened Device Tree)")
        .reserve        = omap_reserve,
        .map_io         = omap243x_map_io,
        .init_early     = omap2430_init_early,
        .init_machine   = omap_generic_init,
        .init_time      = omap2_sync32k_timer_init,
        .dt_compat      = omap243x_boards_compat,
        .restart        = omap2xxx_restart,
MACHINE_END
#endif
```

平台标识 - dts与machine匹配

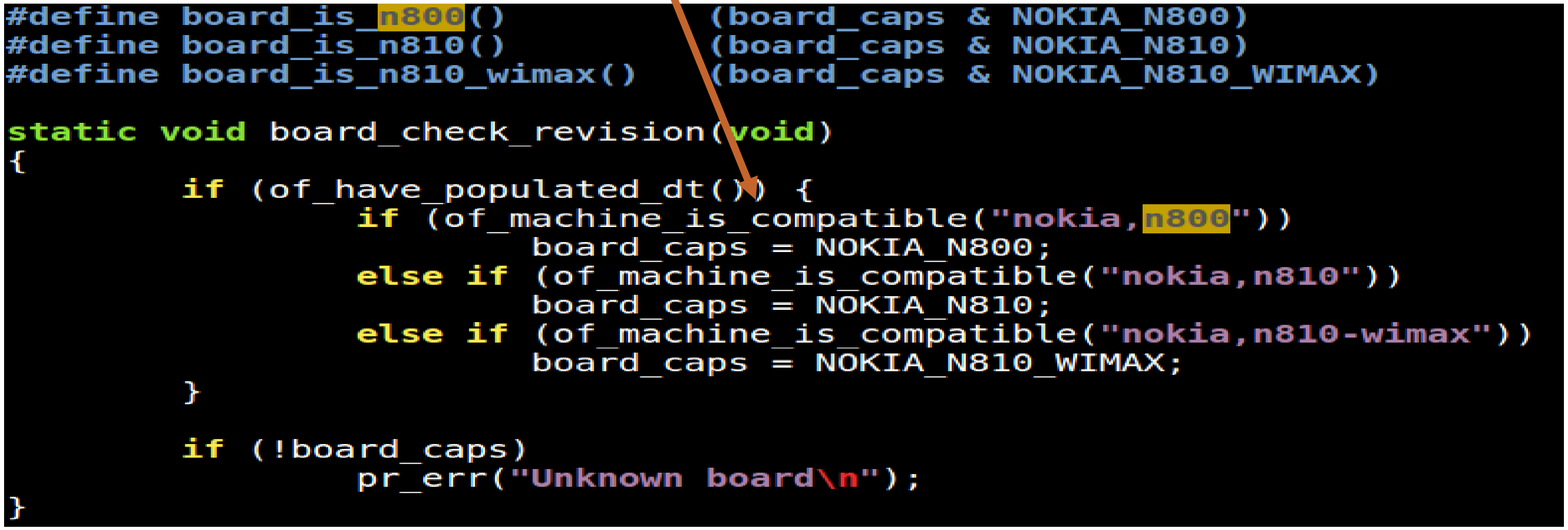
omap2420-n800.dts

匹配common machine



```
/dts-v1/;

#include "omap2420-n8x0-common.dtsi"

/ {
        model = "Nokia N800";
        compatible = "nokia,n800", "nokia,n8x0", "ti,omap2420", "ti,omap2";
};
```

从具体到抽象



```
#define board_is_n800()         (board_caps & NOKIA_N800)
#define board_is_n810()         (board_caps & NOKIA_N810)
#define board_is_n810_wimax()   (board_caps & NOKIA_N810_WIMAX)

static void board_check_revision(void)
{
        if (of_have_populated_dt()) {
                if (of_machine_is_compatible("nokia,n800"))
                        board_caps = NOKIA_N800;
                else if (of_machine_is_compatible("nokia,n810"))
                        board_caps = NOKIA_N810;
                else if (of_machine_is_compatible("nokia,n810-wimax"))
                        board_caps = NOKIA_N810_WIMAX;
        }

        if (!board_caps)
                pr_err("Unknown board\n");
}
```

运行时配置-U-Boot修改dtb

用户设置bootargs

```
int fdt_chosen(void *fdt)
{
        int   nodeoffset;
        int   err;
        char  *str;                /* used to set string properties */

        err = fdt_check_header(fdt);
        ...

        /* find or create "/chosen" node. */
        nodeoffset = fdt_find_or_add_subnode(fdt, 0, "chosen");
        ...

        str = getenv("bootargs");
        if (str) {
                err = fdt_setprop(fdt, nodeoffset, "bootargs", str,
                                        strlen(str) + 1);
                ...
        }

        ...
}
```

运行时配置 - U-Boot设备树相关命令

```
#define CONFIG_OF_LIBFDT            /* Device Tree support */
```

```
Usage:
fdt addr <addr> [<length>] - Set the fdt location to <addr>
fdt move <fdt> <newaddr> <length> - Copy the fdt to <addr> and make it active
fdt resize - Resize fdt to size + padding to 4k addr
fdt print <path> [<prop>] - Recursive print starting at <path>
fdt list <path> [<prop>] - Print one level starting at <path>
fdt set <path> <prop> [<val>] - Set <property> [to <val>]
fdt mknode <path> <node> - Create a new node after <path>
fdt rm <path> [<prop>] - Delete the node or <property>
fdt header - Display header info
fdt bootcpu <id> - Set boot cpuid
fdt memory <addr> <size> - Add/Update memory node
fdt rsvmem print - Show current mem reserves
fdt rsvmem add <addr> <size> - Add a mem reserve
fdt rsvmem delete <index> - Delete a mem reserves
fdt chosen [<start> <end>] - Add/update the /chosen branch in the tree
```

设 备 信 息 - 展开platform_device

customize_machine()或者init_machine()会调用of_platform_populate()函数会为“simple-bus”节点生成和展开platform_device

```
struct platform_device *of_device_alloc(struct device_node *np,
                                        const char *bus_id,
                                        struct device *parent)
{
        struct platform_device *dev;
        int rc, i, num_reg = 0, num_irq;
        struct resource *res, temp_res;

        dev = platform_device_alloc("", -1);
        if (!dev)
                return NULL;

        /* count the io and irq resources */
        while (of_address_to_resource(np, num_reg, &temp_res) == 0)
                num_reg++;
        num_irq = of_irq_count(np);

        /* Populate the resource table */
        if (num_irq || num_reg) {
                res = kzalloc(sizeof(*res) * (num_irq + num_reg), GFP_KERNEL);
                ...
                dev->num_resources = num_reg + num_irq;
                dev->resource = res;
                for (i = 0; i < num_reg; i++, res++) {
                        rc = of_address_to_resource(np, i, res);
                        WARN_ON(rc);
                }
                if (of_irq_to_resource_table(np, res, num_irq) != num_irq)
                        ...
        }
        ...
}
```

设备驱动模型连本质都没有变!

设备信息 -展开i2c子节点

i2c_register_adapter()函数会调用of_i2c_register_devices()生成和展开i2c device

```
static struct i2c_client *of_i2c_register_device(struct i2c_adapter *adap,
                                                struct device_node *node)
{
        ...
        if (of_modalias_node(node, info.type, sizeof(info.type)) < 0) {
                ...
        }

        addr = of_get_property(node, "reg", &len);
        ...
        info.addr = be32_to_cpup(addr);
        ...
        result = i2c_new_device(adap, &info);
        ...
        return result;
}
```

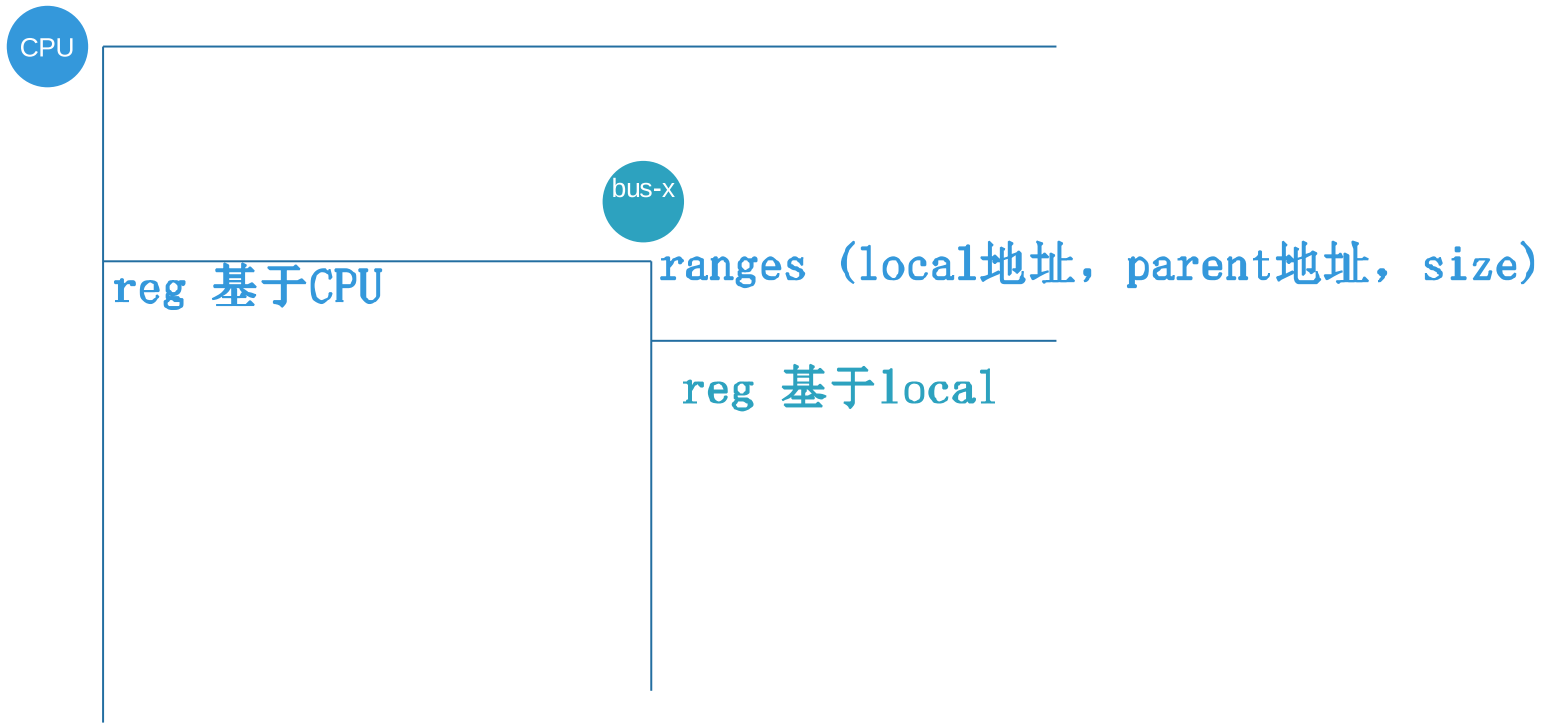
设备信息-展开spi子节点

spi_register_master()函数会调用of_register_spi_devices()为子节点生成和展开spi device

```
static void of_register_spi_devices(struct spi_master *master)
{
	...

	for_each_available_child_of_node(master->dev.of_node, nc) {
		spi = of_register_spi_device(master, nc);
		if (IS_ERR(spi))
			dev_warn(&master->dev, "Failed to create SPI device for %s\n",
				nc->full_name);
	}
}

static struct spi_device *
of_register_spi_device(struct spi_master *master, struct device_node *nc)
{

	rc = of_property_read_u32(nc, "reg", &value);
	if (rc) {
		dev_err(&master->dev, "%s has no valid 'reg' property (%d)\n",
			nc->full_name, rc);
		goto err_out;
	}
	spi->chip_select = value;
	rc = spi_add_device(spi);
	...
}
```

ranges

ranges代表了local地址向parent地址的转换;
ranges为空代表1:1映射;
无range代表不是memory map区域



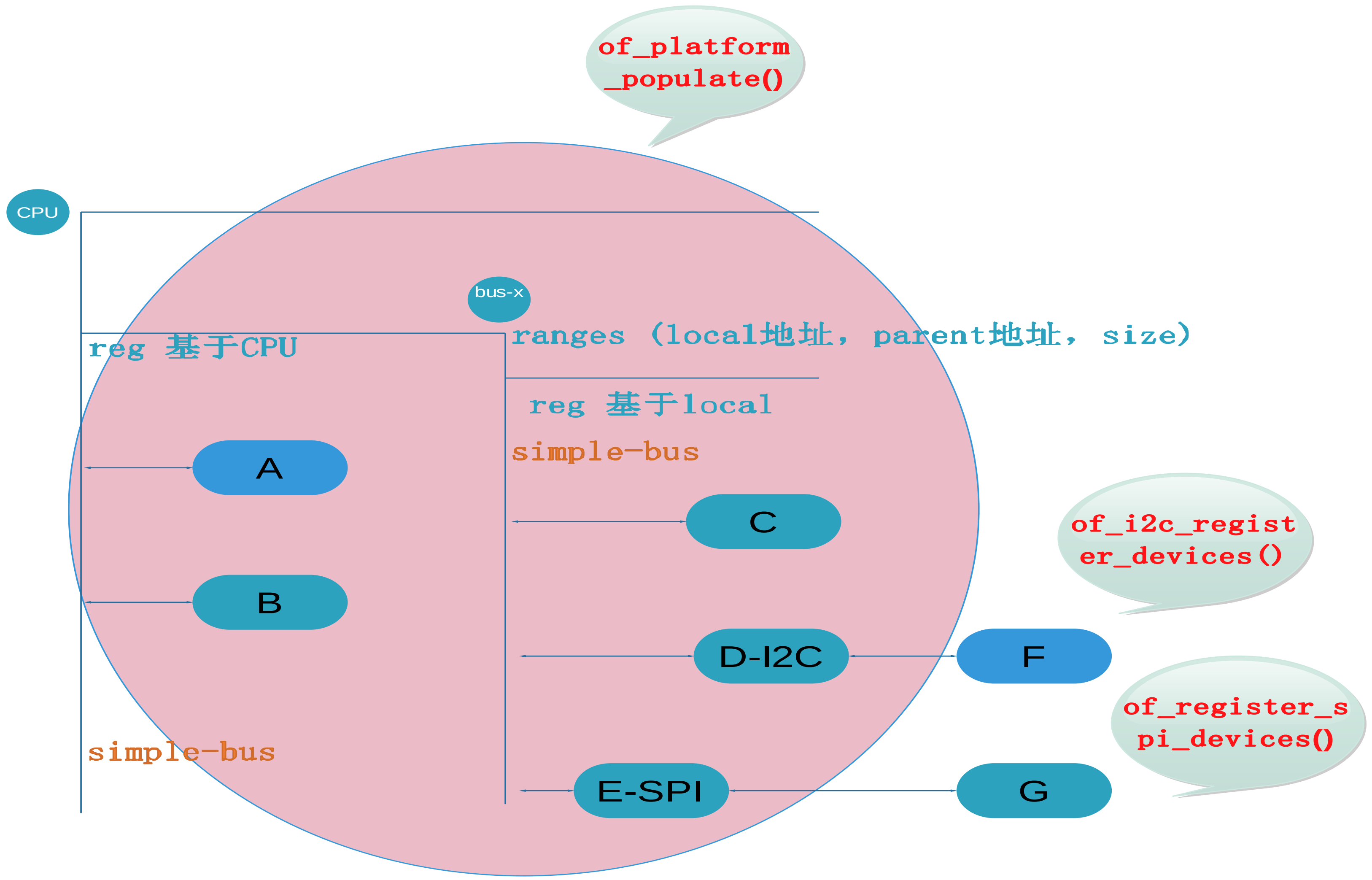
ranges(cont.)

0映射到0x19020000

```
mpcore {
        compatible = "simple-bus";
        ranges = <0x00000000 0x19020000 0x00003000>;
        #address-cells = <1>;
        #size-cells = <1>;

        scu@0000 {
                compatible = "arm,cortex-a9-scu";
                reg = <0x0000 0x100>;
        };

        timer@0200 {
                compatible = "arm,cortex-a9-global-timer";
                reg = <0x0200 0x100>;
                interrupts = <GIC_PPI 11 IRQ_TYPE_LEVEL_HIGH>;
                clocks = <&clk_periph>;
        };
}
```

timer映射到0x19020200

各级设备的展开


of_platform_populate()
CPU
bus-x
ranges (local地址, parent地址, size)
reg 基于CPU
reg 基于local
simple-bus
A
C
of_i2c_register_devices()
B
D-I2C
F
of_register_spi_devices()
simple-bus
E-SPI
G

dts和driver的 匹 配

```
eth: eth@4,c00000 {
        compatible = "davicom,dm9000";
        ...
    };
```

```
#ifdef CONFIG_OF
static const struct of_device_id dm9000_of_matches[] = {
	{ .compatible = "davicom,dm9000", },
	{ /* sentinel */ }
};
MODULE_DEVICE_TABLE(of, dm9000_of_matches);
#endif

static struct platform_driver dm9000_driver = {
	.driver = {
		.name    = "dm9000",
		.pm      = &dm9000_drv_pm_ops,
		.of_match_table = of_match_ptr(dm9000_of_matches),
	},
	.probe   = dm9000_probe,
	.remove  = dm9000_drv_remove,
};
```

总 线match函 数

```
static int platform_match(struct device *dev, struct device_driver *drv)
{
	struct platform_device *pdev = to_platform_device(dev);
	struct platform_driver *pdrv = to_platform_driver(drv);

	/* When driver_override is set, only bind to the matching driver */
	if (pdev->driver_override)
		return !strcmp(pdev->driver_override, drv->name);

	/* Attempt an OF style match first */
	if (of_driver_match_device(dev, drv))
		return 1;

	/* Then try ACPI style match */
	if (acpi_driver_match_device(dev, drv))
		return 1;

	/* Then try to match against the id table */
	if (pdrv->id_table)
		return platform_match_id(pdrv->id_table, pdev) != NULL;

	/* fall-back to driver name match */
	return (strcmp(pdev->name, drv->name) == 0);
}
```

硬件描述数据

drivers/dma/sun6i-dma.c

```
static struct sun6i_dma_config sun8i_a23_dma_cfg = {
        .nr_max_channels = 8,
        .nr_max_requests = 24,
        .nr_max_vchans   = 37,
};
static struct of_device_id sun6i_dma_match[] = {
        { .compatible = "allwinner,sun6i-a31-dma", .data = &sun6i_a31_dma_cfg },
        { .compatible = "allwinner,sun8i-a23-dma", .data = &sun8i_a23_dma_cfg },
        { /* sentinel */ }
};

static int sun6i_dma_probe(struct platform_device *pdev)
{
        ...

        device = of_match_device(sun6i_dma_match, &pdev->dev);
        if (!device)
                return -ENODEV;
        sdc->cfg = device->data;
}
```

sun8i-a23.dtsi

```
dma: dma-controller@01c02000 {
  compatible = "allwinner,sun8i-a23-dma";
}
```

sun6i-a31.dtsi

```
dma: dma-controller@01c02000 {
 compatible = "allwinner,sun6i-a31-dma";
 reg = <0x01c02000 0x1000>;
}
```

reg(寄 存 器 等)

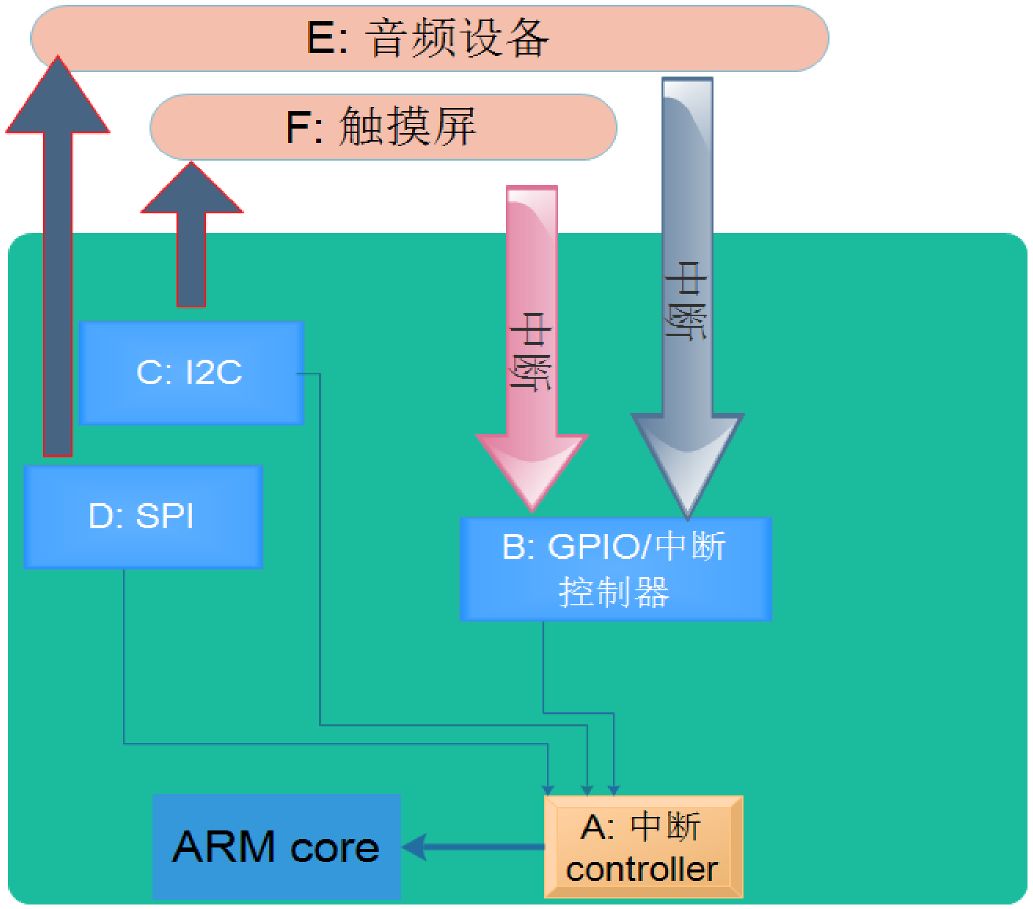
```
soc@0 {
        #address-cells = <1>;
        #size-cells = <1>;
        compatible = "intel,ce4100-cp";
        ranges;

        ioapic1: interrupt-controller@fec00000 {
                #interrupt-cells = <2>;
                compatible = "intel,ce4100-ioapic";
                interrupt-controller;
                reg = <0xfec00000  0x1000>;
        };
```

```
cpus {
        #address-cells = <1>;
        #size-cells = <0>;

        cpu@0 {
                device_type = "cpu";
                compatible = "intel,ce4100";
                reg = <0>;
                lapic = <&lapic0>;
        };
    };
```

```
i2c-controller@b,2 {
    #address-cells = <2>;
    #size-cells = <1>;
    ...

    i2c@0 {
        reg = <0 0 0x100>;
    };
}
```

中 断

- ✓ B、C、D的interrupt-parent是A；
- ✓ E、F的interrupt-parent是B



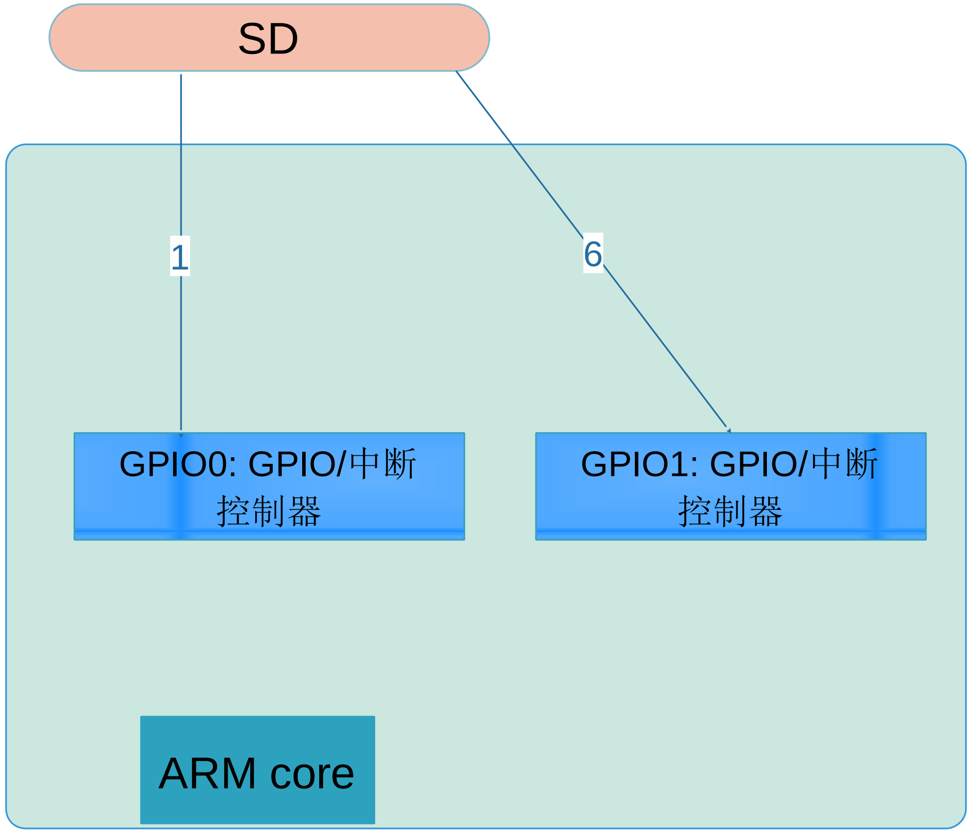
```
/ {
        #address-cells = <1>;
        #size-cells = <1>;

        compatible = "ti,dra7xx";
        interrupt-parent = <&gic>;
        ...
}
```

```
gpio1: gpio@4ae10000 {
    compatible = "ti,omap4-gpio";
    reg = <0x4ae10000 0x200>;
    interrupts = <GIC_SPI 24
IRQ_TYPE_LEVEL_HIGH>;
    gpio-controller;
    #gpio-cells = <2>;
    interrupt-controller;
    #interrupt-cells = <2>;
};
```

```
tps659038: tps659038@58 {
  compatible = "ti,tps659038";
  reg = <0x58>;
  interrupt-parent = <&gpio1>;
  interrupts = <0 IRQ_TYPE_LEVEL_LOW>;
}
```

GPIO,DMA, CLK，pinctrl描述方式

硬件



驱动

```
of_get_named_gpio(np, "cd-gpios", 0);

of_get_named_gpio(np, "wp-gpios", 0);
```

dts

```
wp-gpios = <&gpio0 1
                GPIO_ACTIVE_HIGH>;
wp-gpios = <&gpio1 6
                GPIO_ACTIVE_HIGH>;

gpio0: gpio@e0050000 {
        ...
        gpio-controller;
        #gpio-cells = <2>;
        ngpios = <32>;
        ...
    };
    gpio1: gpio@e0050080 {
        ...
        gpio-controller;
        #gpio-cells = <2>;
        ngpios = <32>;
        ...
    };
```

DEMO和案例

加一个新的SoC和DTS

- ✓ 新建一个目录：arch/arm/mach-demosoc
- ✓ 加arch/arm/mach-demosoc/Kconfig、Makefile

```
config ARCH_DEMOSOC
        bool "Linuxer demo soc(made by baohua)"
        help
          Support for Linuxer demo soc(made by baohua)
```

- ✓ 加arch/arm/mach-demosoc/common.c

```
static void __init demosoc_init_late(void)
{
}

#ifdef CONFIG_ARCH_DEMOSOC
static const char *const demosoc_dt_match[] __initconst = {
        "linuxer,demosoc",
        NULL
};

DT_MACHINE_START(DEMOSOC_DT, "Linuxer DEMOSOC (Flattened Device Tree)")
        /* Maintainer: Barry Song <baohua@kernel.org> */
        .init_late      = demosoc_init_late,
        .dt_compat      = demosoc_dt_match,
MACHINE_END
#endif
```

加一个新的SoC和DTS(cont.)

- ✓ 加dtsi和dts

linuxer-demosoc.dtsi
linuxer-demosoc-evb.dts

- ✓ 把dts编译

修改：
arch/arm/boot/dts/Makefile

```
dtb-$(CONFIG_MACH_DEMOSOOC) += \
        linuxer-demosoc-evb.dtb
```

- ✓ 反编译dtb

fdtdump linuxer-demosoc-evb.dtb
或者
dtc –I dtb –O dts ….

阅读与其他参考资料

《Linux总线、设备、驱动模型》直播PPT分享

让天堂的归天堂，让尘土的归尘土——谈Linux的总线、设备、驱动模型

http://www.devicetree.org/Device_Tree_Usage

http://events.linuxfoundation.org/sites/events/files/slides/petazzoni-device-tree-dummies.pdf

《Linux总线、设备、驱动模型》录播：
http://edu.csdn.net/course/detail/5329

谢 谢！