PRU中断

芯片手册pru中断相关架构图

30.1.6.1 PRU-ICSS Interrupt Controller Overview

The PRU-ICSS interrupt controller (PRUSS_INTC) maps interrupts coming from different parts of the device (mapped to PRU-ICSS1/PRU-ICSS2 via the device IRQ_CROSSBAR) to a reduced set of PRU-ICSS interrupt channels.

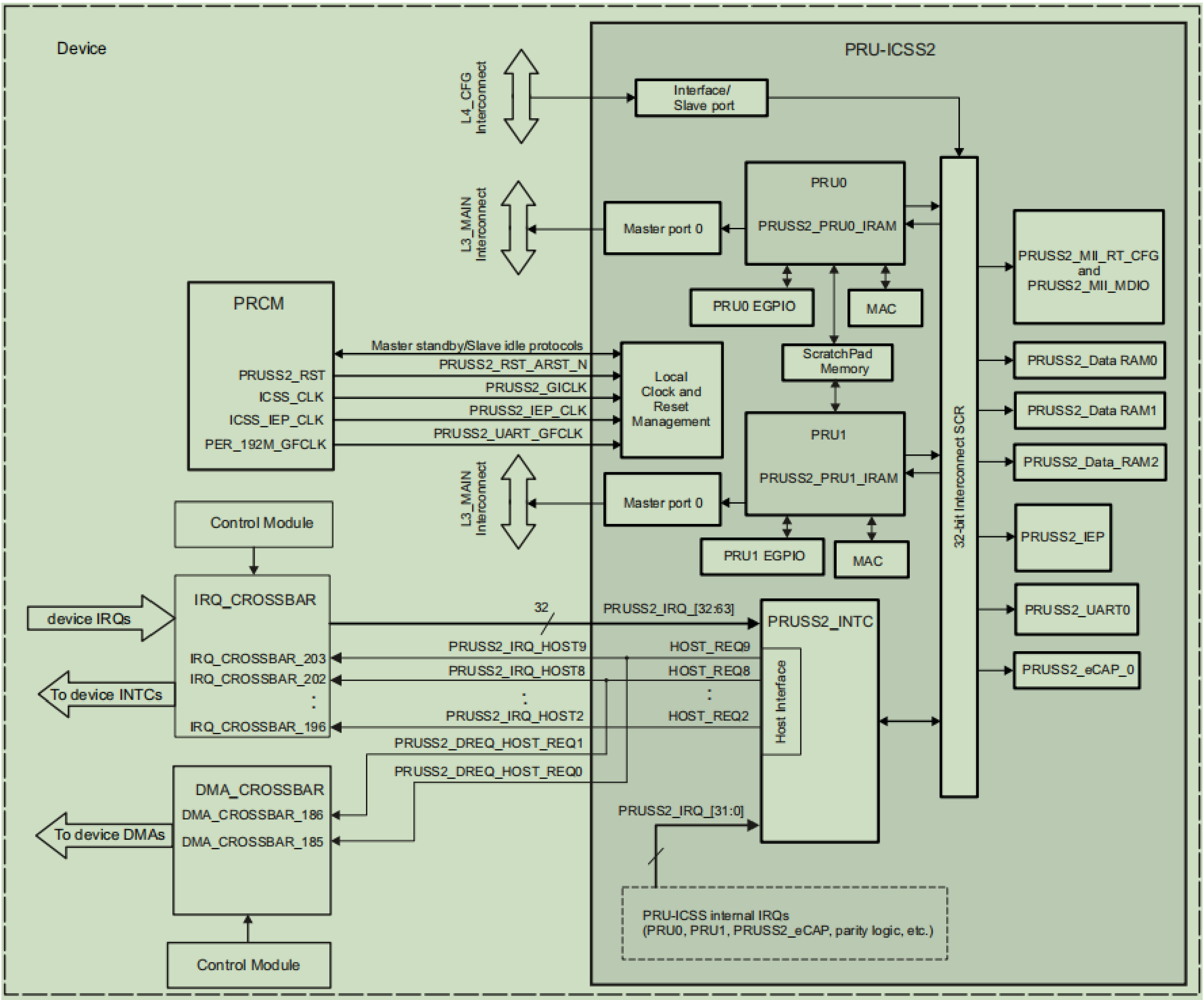
The PRUSS_INTC has the following features:

- Capturing up to 64 System Events (inputs)
- Supports up to 10 output interrupt channels.
- Generation of 10 Host Interrupts
  - 2 Host Interrupts for the PRUs.
  - 8 Host Interrupts exported from the PRU-ICSS for signaling the ARMSS interrupt controllers.
- Each system event can be enabled and disabled.
- Each host event can be enabled and disabled.
- Hardware prioritization of events.

30.1.6.2 PRU-ICSS Interrupt Controller Functional Description

The PRU-ICSS incorporates an interrupt controller - PRUSS_INTC that supports up to 64 system interrupts from different peripherals (including 32 interrupts from PRU-ICSS located interrupt sources). The PRUSS_INTC maps these system events to 10 channels inside the PRUSS_INTC (see Figure 30-18). Interrupts from these 10 channels are further mapped to 10 Host Interrupts.

- Any of the 64 system interrupts can be mapped to any of the 10 channels.
- Multiple interrupts can be mapped to a single channel.
- An interrupt should not be mapped to more than one channel.
- Any of the 10 channels can be mapped to any of the 10 host interrupts. It is recommended to map channel “x” to host interrupt “x”, where x is from 0 to 9
- A channel should not be mapped to more than one host interrupt
- For channels mapping to the same host interrupt, lower number channels have higher priority.
- For interrupts on same channel, priority is determined by the hardware interrupt number. The lower the interrupt number, the higher the priority.
- Host Interrupt 0 is connected to bit 30 in register 31 (R31) of PRU0 and PRU1.
- Host Interrupt 1 is connected to bit 31 in register 31 (R31) for PRU0 and PRU1.
- Host Interrupts 2 through 9 exported from PRU-ICSS and mapped to interrupt controllers in the device.



Device
PRU-ICSS2
L4_CFG Interconnect
Interface/ Slave port
L3_MAIN Interconnect
Master port 0
PRU0
PRUSS2_PRU0_IRAM
PRU0 EGPIO
MAC
PRUSS2_MII_RT_CFG and PRUSS2_MII_MDIO
PRCM
PRUSS2_RST
ICSS_CLK
ICSS_IEP_CLK
PER_192M_GFCLK
Master standby/Slave idle protocols
PRUSS2_RST_ARST_N
PRUSS2_GICLK
PRUSS2_IEP_CLK
PRUSS2_UART_GFCLK
Local Clock and Reset Management
ScratchPad Memory
PRUSS2_Data RAM0
PRUSS2_Data RAM1
PRUSS2_Data_RAM2
PRU1
PRUSS2_PRU1_IRAM
32-bit Interconnect SCR
Control Module
PRU1 EGPIO
MAC
PRUSS2_IEP
IRQ_CROSSBAR
device IRQs
32
PRUSS2_IRQ_[32:63]
PRUSS2_INTC
PRUSS2_UART0
IRQ_CROSSBAR_203
IRQ_CROSSBAR_202
IRQ_CROSSBAR_196
To device INTCs
PRUSS2_IRQ_HOST9
PRUSS2_IRQ_HOST8
PRUSS2_IRQ_HOST2
HOST_REQ9
HOST_REQ8
HOST_REQ2
Host Interface
PRUSS2_eCAP_0
PRUSS2_DREQ_HOST_REQ1
PRUSS2_DREQ_HOST_REQ0
DMA_CROSSBAR
DMA_CROSSBAR_186
DMA_CROSSBAR_185
To device DMAs
PRUSS2_IRQ_[31:0]
PRU-ICSS internal IRQs
(PRU0, PRU1, PRUSS2_eCAP, parity logic, etc.)
Control Module

Figure 30-18. PRU-ICSS Interrupt Controller Block Diagram

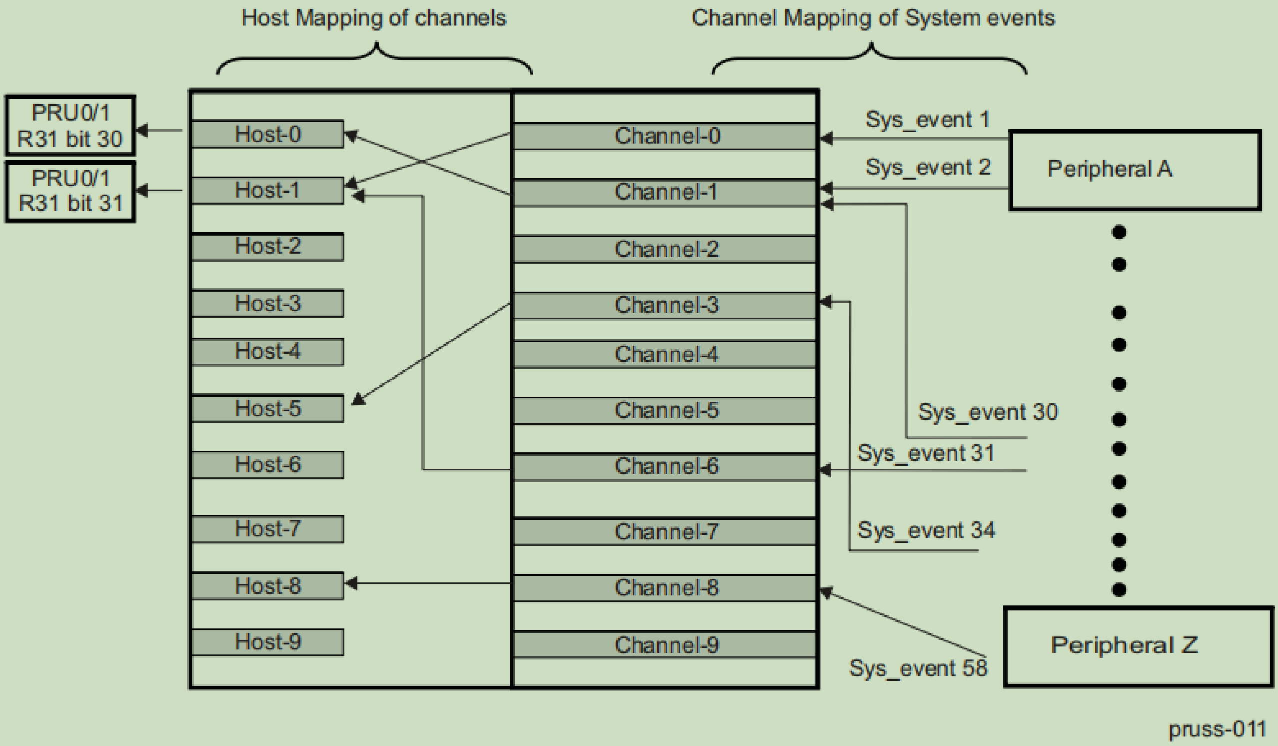


Table 30-5. PRU-ICSS Hardware Requests

Interrupt Requests				
Module Instance	**Source Signal Name**	**IRQ_CROSSBAR Input**	**Default Mapping**	**Description**
PRU-ICSS1	PRUSS1_IRQ_HOST2[1]	IRQ_CROSSBAR_186	-	PRU-ICSS1 Host interrupt 2
	PRUSS1_IRQ_HOST3[1]	IRQ_CROSSBAR_187	-	PRU-ICSS1 Host interrupt 3
	PRUSS1_IRQ_HOST4[1]	IRQ_CROSSBAR_188	-	PRU-ICSS1 Host interrupt 4
	PRUSS1_IRQ_HOST5[1]	IRQ_CROSSBAR_189	-	PRU-ICSS1 Host interrupt 5
	PRUSS1_IRQ_HOST6[1]	IRQ_CROSSBAR_190	-	PRU-ICSS1 Host interrupt 6
	PRUSS1_IRQ_HOST7[1]	IRQ_CROSSBAR_191	-	PRU-ICSS1 Host interrupt 7
	PRUSS1_IRQ_HOST8[1]	IRQ_CROSSBAR_192	-	PRU-ICSS1 Host interrupt 8
	PRUSS1_IRQ_HOST9[1]	IRQ_CROSSBAR_193	-	PRU-ICSS1 Host interrupt 9
PRU-ICSS2	PRUSS2_IRQ_HOST2[1]	IRQ_CROSSBAR_196	-	PRU-ICSS2 Host interrupt 2
	PRUSS2_IRQ_HOST3[1]	IRQ_CROSSBAR_197	-	PRU-ICSS2 Host interrupt 3
	PRUSS2_IRQ_HOST4[1]	IRQ_CROSSBAR_198	-	PRU-ICSS2 Host interrupt 4
	PRUSS2_IRQ_HOST5[1]	IRQ_CROSSBAR_199	-	PRU-ICSS2 Host interrupt 5
	PRUSS2_IRQ_HOST6[1]	IRQ_CROSSBAR_200	-	PRU-ICSS2 Host interrupt 6
	PRUSS2_IRQ_HOST7[1]	IRQ_CROSSBAR_201	-	PRU-ICSS2 Host interrupt 7
	PRUSS2_IRQ_HOST8[1]	IRQ_CROSSBAR_202	-	PRU-ICSS2 Host interrupt 8
	PRUSS2_IRQ_HOST9[1]	IRQ_CROSSBAR_203	-	PRU-ICSS2 Host interrupt 9

PRUSS2_IRQ_19	pr2_pru_mst_intr[3]_intr_req	pru0 or pru1
PRUSS2_IRQ_18	pr2_pru_mst_intr[2]_intr_req	pru0 or pru1
PRUSS2_IRQ_17	pr2_pru_mst_intr[1]_intr_req	pru0 or pru1
PRUSS2_IRQ_16	pr2_pru_mst_intr[0]_intr_req	pru0 or pru1

pru中断相关设备树信息

```
/ {
```

```
    #address-cells = <2>;
    #size-cells = <2>;

    compatible = "ti,dra7xx";
    interrupt-parent = <&crossbar_mpu>;      //
    .....

     gic: interrupt-controller@48211000 {
        compatible = "arm,cortex-a15-gic";
        interrupt-controller;
        #interrupt-cells = <3>;
        reg = <0x0 0x48211000 0x0 0x1000>,
              <0x0 0x48212000 0x0 0x2000>,
              <0x0 0x48214000 0x0 0x2000>,
              <0x0 0x48216000 0x0 0x2000>;
        interrupts = <GIC_PPI 9 (GIC_CPU_MASK_SIMPLE(2) | IRQ_TYPE_LEVEL_HIGH)>;
        interrupt-parent = <&gic>;
    };        /* gic节点,第1层  */

    wakeupgen: interrupt-controller@48281000 {
        compatible = "ti,omap5-wugen-mpu", "ti,omap4-wugen-mpu";
        interrupt-controller;
        #interrupt-cells = <3>;
        reg = <0x0 0x48281000 0x0 0x1000>;
        interrupt-parent = <&gic>;
    };       /* wakeupgen节点,第1层  */

    .....

    ocp {
        compatible = "ti,dra7-l3-noc", "simple-bus";
        #address-cells = <1>;
        #size-cells = <1>;
        ranges = <0x0 0x0 0x0 0xc0000000>;
        ti,hwmods = "l3_main_1", "l3_main_2";
        reg = <0x0 0x44000000 0x0 0x1000000>,
              <0x0 0x45000000 0x0 0x1000>;
        interrupts-extended = <&crossbar_mpu GIC_SPI 4 IRQ_TYPE_LEVEL_HIGH>,
                      <&wakeupgen GIC_SPI 10 IRQ_TYPE_LEVEL_HIGH>;
        .....

        pruss_soc_bus2: pruss-soc-bus@4b2a6004 {
            compatible = "ti,am5728-pruss-soc-bus";
            reg = <0x4b2a6004 0x4>;
            ti,hwmods = "pruss2";
            #address-cells = <1>;
            #size-cells = <1>;
            ranges;
            status = "disabled";

            pruss2: pruss@4b280000 {
                compatible = "ti,am5728-pruss";
                reg = <0x4b280000 0x80000>;
```

```
interrupts = <GIC_SPI 196 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 197 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 198 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 199 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 200 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 201 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 202 IRQ_TYPE_LEVEL_HIGH>,
<GIC_SPI 203 IRQ_TYPE_LEVEL_HIGH>;
interrupt-names = "host2", "host3", "host4",
"host5", "host6", "host7",
"host8", "host9";
#address-cells = <1>;
#size-cells = <1>;
ranges;
status = "disabled";
/* interrupt-parent没有指明则是父节点的interrupt-parent，最终是crossbar_mpu */
.....

pruss2_intc: interrupt-controller@4b2a0000 {
    compatible = "ti,am5728-pruss-intc";
    reg = <0x4b2a0000 0x2000>;
    interrupt-controller;
    #interrupt-cells = <1>;
};      /* pruss2_intc节点,第4层  */


/* pru0核 */
pru2_0: pru@4b2b4000 {
    compatible = "ti,am5728-pru";
    reg = <0x4b2b4000 0x3000>,
    <0x4b2a2000 0x400>,
    <0x4b2a2400 0x100>;
    reg-names = "iram", "control", "debug";
    firmware-name = "am57xx-pru2_0-fw";
    interrupt-parent = <&pruss2_intc>;
    interrupts = <16>, <17>;    //映射到
    interrupt-names = "vring", "kick";
};      /* pru2_0节点,第4层  */

/* pru1核 */
pru2_1: pru@4b2b8000 {
    compatible = "ti,am5728-pru";
    reg = <0x4b2b8000 0x3000>,
    <0x4b2a4000 0x400>,
    <0x4b2a4400 0x100>;
    reg-names = "iram", "control", "debug";
    firmware-name = "am57xx-pru2_1-fw";
    interrupt-parent = <&pruss2_intc>;
    interrupts = <18>, <19>;    //
    interrupt-names = "vring", "kick";
};      /* pru2_1节点,第4层  */
.....
```

```
            };      /* pruss2节点,第3层  */
            .....

        }; /*pruss_soc_bus2节点,第2层  */
        ......


            : crossbar@4a002a48 {
            compatible = "ti,irq-crossbar";
            reg = <0x4a002a48 0x130>;
            interrupt-controller;
            interrupt-parent = <&wakeupgen>;
            #interrupt-cells = <3>;
            ti,max-irqs = <160>;
            ti,max-crossbar-sources = <MAX_SOURCES>;
            ti,reg-size = <2>;
            ti,irqs-reserved = <0 1 2 3 5 6 131 132>;
            ti,irqs-skip = <10 133 139 140>;
            ti,irqs-safe-map = <0>;
        };      /* crossbar_mpu节点,第2层  */
        .....

    };   /* ocp节点,第1层  */
    .....

} /* /节点,第0层  */
```

芯片厂商pru驱动

　芯片厂商即ti，ti的pru驱动有好几个，但是必须的和在加载pru字符设备驱动前加载的不是全部，只要pruss_int，pruss，pruss_soc_bus。最重要的是pruss_int，它负责配置中断控制器，包括通道映射级联等。这几个驱动的框架都很类似，以下拿pruss_soc_bus举例。
　　如上图设备树，因为pruss-soc-bus的父节点ocp是根结点的直接子节点，所以内核启动会直接将ocp节点转换成platform device，并且ocp节点的compatible中含有simple-bus，所以ocp节点的直接子节点也会转化成platform device。因此pruss-soc-bus节点会在内核初始化阶段就被转化为platform device。

```
static const struct of_device_id pruss_soc_bus_of_match[] = {
    { .compatible = "ti,am3356-pruss-soc-bus", .data = &am335x_data, },
    { .compatible = "ti,am4376-pruss-soc-bus", .data = &am437x_data, },
    { .compatible = "ti,am5728-pruss-soc-bus", .data = &am57xx_data, },
    { .compatible = "ti,k2g-pruss-soc-bus", .data = &k2g_data, },
    { .compatible = "ti,am654-icssg-soc-bus", .data = &k2g_data, },
    { /* sentinel */ },
};
MODULE_DEVICE_TABLE(of, pruss_soc_bus_of_match);

static SIMPLE_DEV_PM_OPS(pruss_soc_bus_pm_ops,
             pruss_soc_bus_suspend, pruss_soc_bus_resume);

static struct platform_driver pruss_soc_bus_driver = {
    .driver = {
```

```
        .name = "pruss-soc-bus",
        .pm = &pruss_soc_bus_pm_ops,
        .of_match_table = pruss_soc_bus_of_match,
    },
    .probe  = pruss_soc_bus_probe,
    .remove = pruss_soc_bus_remove,
};
module_platform_driver(pruss_soc_bus_driver);
```

因此在加载了pruss_soc_bus驱动后就匹配到了pruss-soc-bus节点生成的platform device，因此会调用到pruss_soc_bus_probe。

```
static int pruss_soc_bus_probe(struct platform_device *pdev)
{
    .....

    /* 设置psoc_bus结构体和一些初始化设置 */
    psoc_bus = devm_kzalloc(dev, sizeof(*psoc_bus), GFP_KERNEL);
    .....
    psoc_bus->has_reset = data->has_reset;
    psoc_bus->skip_syscfg = !data->uses_prcm;
    platform_set_drvdata(pdev, psoc_bus);

    .....

    /* 对pruss_soc_bus节点的直接子节点都调用of_platform_bus_create */
    ret = of_platform_populate(node, NULL, NULL, dev);
    if (ret)
        goto fail_of;

    return 0;

.....
}
```

因为对pruss_soc_bus节点的直接子节点都调用of_platform_bus_create，所以pruss节点会被转化为platform device，所以pruss的platform device的驱动也可以按照这种方法对pruss的直接子节点生成platform device。

pru字符设备驱动框架

1.入口函数

```
int __init gree_pruss_init(void)
{
    int ret,rtn;
    void *data = rxbuf;
    void **buf = &data;

    /* 申请pti5728_device，并将pti5728_device->rpdev指向全局变量gree_device_data1的地址，
     * 接下来的许多初始化设置都是往这个地址中填充内容
```

```
 */
pti5728_device = kmalloc(sizeof(struct gree_ti5728_dev),GFP_KERNEL);
pti5728_device->rpdev = &gree_device_data1;


/* 绑定gree_pruss_fops，注册字符设备驱动 */
gree_pruss_dev = MKDEV(major, minor);
ret = register_chrdev_region(gree_pruss_dev, 1, "gree_pruss");
if(ret < 0){
    printk(KERN_ERR "error: register dev_t fail \n");
    return ret ;
}
gree_pruss_cdev = cdev_alloc();
cdev_init(gree_pruss_cdev, &gree_pruss_fops);
ret = cdev_add(gree_pruss_cdev, gree_pruss_dev, 1);
if(ret < 0 ){
    printk(KERN_ERR "[err] error:add cdev fail \n");
    return ret;
}


/* 创建设备节点/dev/gree_pruss */
gree_pruss_class = class_create(THIS_MODULE, "gree_class_pruss");
device_create(gree_pruss_class, NULL, gree_pruss_dev, NULL, "gree_pruss");

.....

/* 从设备树获取device node */
struct device_node *prunode;
prunode = of_find_node_by_path("/ocp/pruss_soc_bus@4b2a6004/pruss@0/pru@34000");

/* 从device node得到kick中断对应的虚拟中断号 */
int irqnum;
irqnum = irq_of_parse_and_map(prunode, 1);

/* 为kick中断注册中断处理函数 */
ret = request_irq(irqnum, pru_int_handler, IRQF_TRIGGER_RISING,
    "pru-int", NULL);

.....

/* 申请映射pru的IO内存，并填入到pti5728_device->rpdev中 */
if(0 != initPruIcss(pti5728_device->rpdev))
    return -1;

/* 先将pru固件从文件系统路径fw_path_2_0拷贝到buf中，
 * 然后再从buf拷贝到pti5728_device->rpdev中设置好的pru内存区域中
 */
if(0 != pruss_pru_download(0,pti5728_device->rpdev,fw_path_2_0,buf,sizeof(rxbuf)))
    return -1;
if(0 != pruss_pru_download(1,pti5728_device->rpdev,fw_path_2_1,buf,sizeof(rxbuf)))
    return -1;
```

```
    /* 设置pti5728_device->rpdev中的共享数据结构的wokrtyoe */
    startPruIcss(pti5728_device->rpdev,0);
    startPruIcss(pti5728_device->rpdev,1);

    /* 使能pru，此时pru开始运行上面拷贝的固件 */
    runPruIcss(pti5728_device->rpdev);

    return 0;
}
```

2.字符设备操作函数

- **gree_pruss_open：**应用程序调用open打开dev/gree_pruss时调用。
- **gree_pruss_write：** 应用程序调用write操作open打开dev/gree_pruss对应的文件描述符时调用
- **gree_pruss_ioctl：** 应用程序调用ioctl操作open打开dev/gree_pruss对应的文件描述符时调用

```
static struct file_operations gree_pruss_fops={
    .owner = THIS_MODULE,
    .open = gree_pruss_open,     /* 应用程序调用open打开dev/gree_pruss时调用 */
    .release = gree_pruss_release,
    .write = gree_pruss_write,   /* 应用程序调用write操作dev/gree_pruss时调用 */
    .unlocked_ioctl = gree_pruss_ioctl, /* 应用程序调用ioctl操作dev/gree_pruss时调用 */
};
```

2.1 gree_pruss_open

```
static int gree_pruss_open(struct inode *inode,struct file *filp)
{
    /* 将入口函数中主要设置的pti5728_device->rpdev赋给filp->private_data，
     * 然后在其他文件操作接口(write,ioctl等)中可以提取出来使用
    */
    filp->private_data = pti5728_device->rpdev;//pti5728_str->rpdev;
    return 0;
}
```

2.2 gree_pruss_write

```
static ssize_t gree_pruss_write(struct file *filp, const char __user * buf, size_t count,
loff_t *f_pos)
{
    struct gree_device_data *pti5728_priv_da;

    u32 *ptr = (u32 *)buf;
    u32 pru_n = *ptr++;
    u32 ptr_in = *ptr;

    /* 提取出pti5728_device->rpdev */
    pti5728_priv_da = filp->private_data;
    if(pru_n < NUMBER_PRU) {
        /* 调用SendFrame将数据发送给pru固件，
         * 其中SendFrame仅仅是将数据放在pru共享内存区域中，
         * pru固件会定期过来读取
```

```
         */
        if(SendFrame(pti5728_priv_da, pru_n, ptr_in) == 0){
            return 0;
        }
        printk(KERN_ERR "[error]gree pruss wirte error \n");
    }
    return -1;
}
```

2.2.1 SendFrame

```
int SendFrame(struct gree_device_data *device_data, u32 pru_n, u32 ptr_in)
{
    u32 ret = 0;
    if(pru_n < NUMBER_PRU && device_data->pru_enable[pru_n]) {
        struct PRU_MII_Data *shared_data = (struct PRU_MII_Data *)(device_data-
>gree_share[pru_n].va);

        /* 将数据从BuffTx[pru_n]写到pru共享内存shared_data->buf_tx中 */
        if(ret = copy_from_user(((char* )(shared_data->buf_tx)), (BuffTx[pru_n]),
(SHARED_MEMORY_SIZE))){
            printk("copy_from_user err\n");
            return -1;
            }

        if(ptr_in < SHARED_MEMORY_SIZE_DWORD) {
            shared_data->txp.tx_ptr_in = ptr_in;
            //printk("[test] send frame[%d] \n",pru_n);
            return 0;
        }
    }
    return -1;
}
```

2.3 gree_pruss_ioctl

```
static long gree_pruss_ioctl(struct file *filp,unsigned int cmd,  unsigned long arg) long
{
    u32 pru_n, n;
    u32 *arg_dw_ptr;

    /* 提取出pti5728_device->rpdev */
    struct gree_device_data *pti5728_priv_da;
    pti5728_priv_da = filp->private_data;

    switch (cmd){
        .....
        /* 将用户传入的arg设置到BuffRx[pru_n]中，
         * 接下来如果使用RecieveFrame就会通过copy_to_user
         * 将数据从pru共享内存拷贝到BuffRx[pru_n]中存放的arg中
         */
        case IOCTL_SET_USER_PAGES_RX1:
```

```
            pru_n = 1;
            AllocBuffer(pti5728_priv_da, pru_n, (u32*)arg, 1);
            break;
        /* 将用户传入的arg设置到BuffTx[pru_n]中，
          * 接下来如果使用SendFrame就会通过copy_from_user
          * 从BuffTx[pru_n]中存放的arg中指定的用户地址取数据放到pru共享内存中
         */
        case IOCTL_SET_USER_PAGES_TX1:
            pru_n = 1;
            AllocBuffer(pti5728_priv_da, pru_n, (u32*)arg, 0);
            break;
        /* 调用收帧函数读取pru固件发送过来的数据 */
        case IOCTL_READ_FRAMES:
#ifdef PRU_INT
            if (!(filp->f_flags & O_NONBLOCK))  /* 阻塞模式 */
                *(u32*)arg = RecieveFrame(pti5728_priv_da, PRU_BLOCK);
            else                            /* 非阻塞模式 */
                *(u32*)arg = RecieveFrame(pti5728_priv_da, *(u32*)arg);
            break;
#else
            *(u32*)arg = RecieveFrame(pti5728_priv_da, *(u32*)arg);
            break;
#endif
        .....
        case IOCTL_SET_WORK_TYPE:
            pru_n = (u32)arg >> 16;
            setWorkType(pti5728_priv_da, pru_n, arg & 0xFF);
            break;
        .....
#ifdef PRU_INT
        /* 设置为非阻塞模式 */
        case IOCTL_SET_PRU_NONBLOCK:
            filp->f_flags |= O_NONBLOCK;
            break;
        /* 设置为阻塞模式 */
        case IOCTL_SET_PRU_BLOCK:
            filp->f_flags &= ~O_NONBLOCK;
            break;
#endif
        default:
            return -1;
    }
    return 0;
}
```

2.3.1 IOCTL_SET_USER_PAGES_RX1和IOCTL_SET_USER_PAGES_TX1

如果传入以上两个命令，则调用AllocBuffer

```
void AllocBuffer(struct gree_device_data *device_data, int pru_n, u32 *arg, int is_rx)
{
    struct PRU_MII_Data *shared_data;
    shared_data = (struct PRU_MII_Data *)(device_data->gree_share[pru_n].va);
```

```
    if(pru_n < NUMBER_PRU && device_data->pru_enable[pru_n]) {
        if(arg == 0) { // adapter is closing
            setWorkType(device_data, pru_n, ewtAutoforward);
        }
        else {      // adapter is opening
            /* 将用户传入的*arg写入BuffRx[pru_n]或者BuffTx[pru_n] */
            if(is_rx == 1)
                BuffRx[pru_n] = *arg;
            }
            else{
                BuffTx[pru_n] = *arg;
            }

            if(!is_rx)
                shared_data->tx_ptrs = 0;
        }
    }
    //printk("[test] alloc buffer success \n");
}
```

2.3.2 IOCTL_READ_FRAMES

如果传入以上命令，则调用RecieveFrame，并根据之前是否设置了阻塞模式而往wait参数传入PRU_BLOCK

```
u32 RecieveFrame(struct gree_device_data *device_data, u32 wait)
{
    u32 pru_n;
    u32 ret = 0;


    /* 根据wait参数决定是否阻塞在等待队列上 */
    if (wait != PRU_BLOCK)
        goto POLL;

    /* 没有数据则挂起进程休眠 */
    printk("go to sleep...........\n");
    wait_event_interruptible(pru_wait, atomic_read(&pru_is_not_empty));
    atomic_set(&pru_is_not_empty, 0);
    printk("now wake up...........\n");

POLL:
    /* 被唤醒了，然后读取数据 */
    for(pru_n = 0; pru_n < NUMBER_PRU; pru_n ++) {

        .....

        if(ret) {
            .....

             /* 将数据传到之前设置到BuffRx[pru_n]的地址中 */
            if ((ret1 = copy_to_user((BuffRx[pru_n]), ((char*)shared_data->buf_rx),
SHARED_MEMORY_SIZE ))){
```

```
                printk("copy_to_user err\n");
                return -1;
            }

            printk("copy data to user ok\n");
            break;
        }

    }

    return ret;

}
```

pru应用

1.主函数

```
int main()
{
    /* 打开pru驱动的设备节点 */
    int fd;
    fd = open("/dev/gree_pruss",O_RDWR);
    printf("\n\r fd:%d \r\n",fd);

    /* 申请发送和接收缓冲区 */
    unsigned char *pBufTx;
    unsigned char *pBufRx;
    pBufTx = (char*)malloc(8100*sizeof(char));
    pBufRx = (char*)malloc(8100*sizeof(char));


#ifdef PRU_INT
    void *res;
    /* 设置对该设备节点的操作为阻塞模式 */
    ioctl(fd,IOCTL_SET_PRU_BLOCK,NULL);
#endif

    /* 将用户发送和接收缓冲区设置到驱动的BuffRx[pru_n]中，设置work type */
    ioctl(fd,IOCTL_SET_USER_PAGES_TX1,(unsigned long)&pBufTx);
    ioctl(fd,IOCTL_SET_USER_PAGES_RX1,(unsigned long)&pBufRx);
    ioctl(fd,IOCTL_SET_WORK_TYPE,(1 << 16) + 0x3);


    /* 创建负责接收固件数据的子线程 */
    zh myArg;
    myArg.fd = fd;
    myArg.pBufRx = pBufRx;
    pthread_t tid;
```

```
    pthread_attr_t attr;
    struct sched_param param = { .sched_priority = 93};
    pthread_attr_init(&attr);
    pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);
    pthread_attr_setinheritsched(&attr, PTHREAD_EXPLICIT_SCHED);
    pthread_attr_setschedpolicy(&attr, SCHED_FIFO);
    pthread_attr_setschedparam(&attr, &param);
    pthread_create(&tid, &attr, (void *)KpaNicTaskReceive, (void *)&myArg);

    /* 每隔一秒发送一次数据给pru，pru固件很快会回数据过来并产生中断 */
    unsigned long buf[2] = {1, 0};
    int i = 0;
    for(i = 0; i<128; i = i + 64)
    {
        pBufTx[i+0] = 0x3c;pBufTx[i+1] = 0x00;pBufTx[i+2] = 0x00;   pBufTx[i+3] = 0x00;
        .....
        pBufTx[i+18] = 0x0e;pBufTx[i+19] = 0x10;
        .....
        buf[1] = buf[1]+16;
        sleep(1);
        write(fd, (char*)buf, 8);
    }

    printf("send message done.................\n");

    /* 主线程等待子线程结束 */
    zh_flag = 1;
    pthread_join(tid, &res);

    return 0;
}
```

2.子线程

```
int KpaNicTaskReceive(void* hArg)
{
    /* 获取打开的/dev/gree_pruss文件描述符 */
    int fd = (int)(pArg->fd);
    .....

    while(1)
    {
        .....
         /* 调用到驱动中的RecieveFrame，并传入PRU_BLOCK */
        ioctl(fd, IOCTL_READ_FRAMES, &ret_drv);
        .....

         /* 打印接收到的pru固件发送过来的数据 */
        unsigned long pru_n = (ret_drv >> 15) & 0x01;
        unsigned long ptr_in = ret_drv & 0x3FFF;
        unsigned long ptr_out = (ret_drv >> 16) & 0x3FFF;
```

```c
        if(ptr_in != ptr_out)
        {
            .....
            for(i = 0; i < size + 12; i++)
            {
                printf(" ptr[%d]:%02x ",i,ptr[i]);
            }
            printf("\n");
        }

        if(zh_flag == 1)
        {
            printf("recv message done............................\n");
            break;
        }
    }

    return 0;
}
```

测试结果

先insmod pru_fw_download-03patch.ko，然后./prutest_patch得到如下结果：

```
root@am57xx-evm:~# ./prutest_patch

 fd:3
[   53.457683] go to sleep...........
app sleep.........
[   54.457798] pru int has come...........
[   54.461678] now wake up...........
[   54.465200] copy data to user ok
app wake up.......
[   54.468607] go to sleep

 ret_drv:32786

 offset:0

 ptr:0x88220 size:60
 ptr[0]:3c  ptr[1]:00  ptr[2]:00  ptr[3]:00  ptr[4]:7c  ptr[5]:cb  ptr[6]:2a  ptr[7]:57  ptr[8]:00  ptr[9]:00  ptr[
10]:00  ptr[11]:00  ptr[12]:ff  ptr[13]:ff  ptr[14]:ff  ptr[15]:ff  ptr[16]:ff  ptr[17]:ff  ptr[18]:02  ptr[19]:00
 ptr[20]:00  ptr[21]:00  ptr[22]:00  ptr[23]:00  ptr[24]:88  ptr[25]:a4  ptr[26]:0e  ptr[27]:10  ptr[28]:07  ptr[29
]:00  ptr[30]:01  ptr[31]:00  ptr[32]:00  ptr[33]:00  ptr[34]:02  ptr[35]:00  ptr[36]:00  ptr[37]:00  ptr[38]:c0  p
tr[39]:57  ptr[40]:01  ptr[41]:00  ptr[42]:00  ptr[43]:00  ptr[44]:00  ptr[45]:00  ptr[46]:00  ptr[47]:00  ptr[48]:
00  ptr[49]:00  ptr[50]:00  ptr[51]:00  ptr[52]:00  ptr[53]:00  ptr[54]:00  ptr[55]:00  ptr[56]:00  ptr[57]:00  ptr
[58]:00  ptr[59]:00  ptr[60]:00  ptr[61]:00  ptr[62]:00  ptr[63]:00  ptr[64]:00  ptr[65]:00  ptr[66]:00  ptr[67]:00
  ptr[68]:00  ptr[69]:00  ptr[70]:00  ptr[71]:00
app sleep.........
send message done..................[   55.457927] pru int has come...........
[   55.464747] now wake up...........

[   55.468257] copy data to user ok
app wake up.......

 ret_drv:1212452

 offset:72

 ptr:0x88268 size:60
 ptr[0]:3c  ptr[1]:00  ptr[2]:00  ptr[3]:00  ptr[4]:d0  ptr[5]:e9  ptr[6]:16  ptr[7]:63  ptr[8]:00  ptr[9]:00  ptr[
10]:00  ptr[11]:00  ptr[12]:ff  ptr[13]:ff  ptr[14]:ff  ptr[15]:ff  ptr[16]:ff  ptr[17]:ff  ptr[18]:02  ptr[19]:00
 ptr[20]:00  ptr[21]:00  ptr[22]:00  ptr[23]:00  ptr[24]:88  ptr[25]:a4  ptr[26]:0e  ptr[27]:10  ptr[28]:07  ptr[29
]:00  ptr[30]:01  ptr[31]:00  ptr[32]:00  ptr[33]:00  ptr[34]:02  ptr[35]:00  ptr[36]:00  ptr[37]:00  ptr[38]:c0  p
tr[39]:97  ptr[40]:01  ptr[41]:00  ptr[42]:00  ptr[43]:00  ptr[44]:00  ptr[45]:00  ptr[46]:00  ptr[47]:00  ptr[48]:
00  ptr[49]:00  ptr[50]:00  ptr[51]:00  ptr[52]:00  ptr[53]:00  ptr[54]:00  ptr[55]:00  ptr[56]:00  ptr[57]:00  ptr
[58]:00  ptr[59]:00  ptr[60]:00  ptr[61]:00  ptr[62]:00  ptr[63]:00  ptr[64]:00  ptr[65]:00  ptr[66]:00  ptr[67]:00
  ptr[68]:00  ptr[69]:00  ptr[70]:00  ptr[71]:00
recv message done............................
root@am57xx-evm:~#
```

位于__vectors_start和__vectors_end之间；

结果显示正确。