Embedded Systems Programming

Linux GPIO & I2C Drivers (Module 13)

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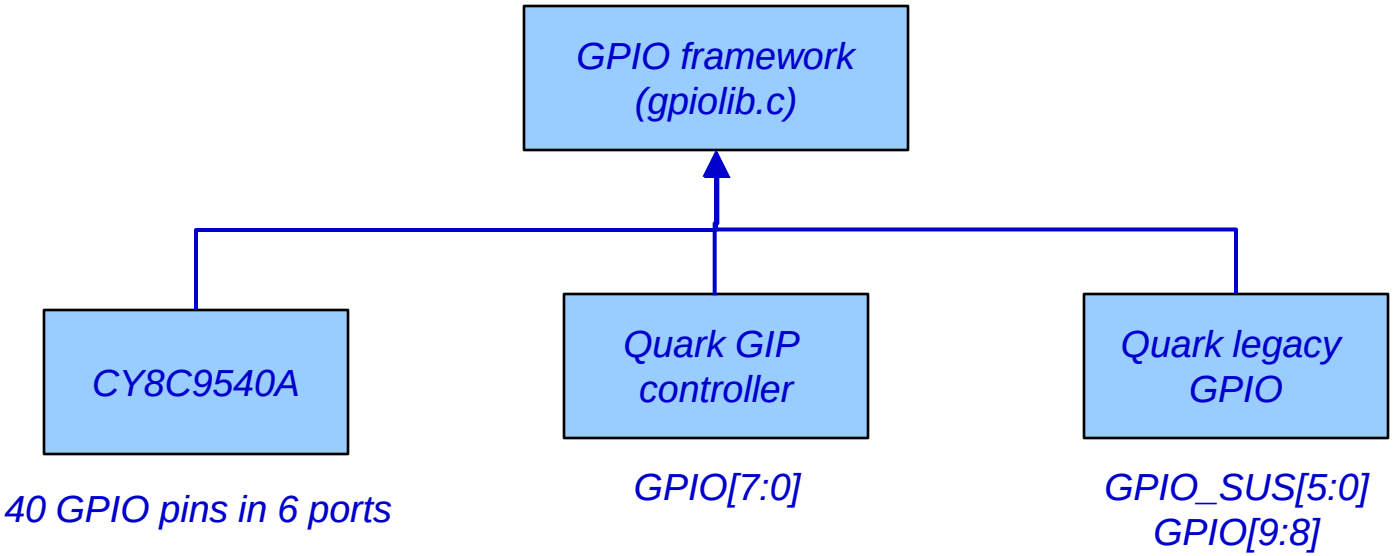
Summer 2014

Linux GPIO Driver

- A GPIO (General Purpose Input/Output) pin can be configured, set up its direction, and value if it is an output pin
- A SoC chip may have several GPIO components
  - Multiple “gpio chips”
- A global number in the integrated GPIO namespace, i.e., 0, 1, 2,…,n
- sysfs interface to user space



GPIO Chip Driver

- **A driver for each GPIO controller to provide**
  - methods to establish GPIO direction and to access GPIO values
  - method to return the IRQ number associated to a given GPIO
  - flag saying whether calls to its methods may sleep
  - optional base number
- **In intel_qrk_gip_gpio.c**

```
/* The base GPIO number under GPIOLIB framework */
#define INTEL_QRK_GIP_GPIO_BASE        8
/* The default number of South-Cluster GPIO on Quark. */
#define INTEL_QRK_GIP_NGPIO            8
```

- **In include/linux/gpio/driver.h, “gpio_chip” is defined, including**
  - base: identifies the first GPIO number handled by this chip.
  - ngpio: the number of GPIOs handled by this controller; the last GPIO handled is (base + ngpio - 1).

GPIO Driver Operation

- **GPIO chip driver request to add "gpio_chip" to the platform**

  gc->base = pdata->gpio_base;

  gc->ngpio = NGPIO;

  ret = gpiochip_add(&dev->gpio_chip);

- ***gpiolib.c* exports methods to work on GPIO pins**
  - **from GPIO # to find chip and to invoke teh corresponding methods provided by the chip**

    gpio_request_one(LED1, GPIOF_OUT_INIT_LOW, "led1");

    gpio_desc desc1 = gpio_to_desc(LED1);

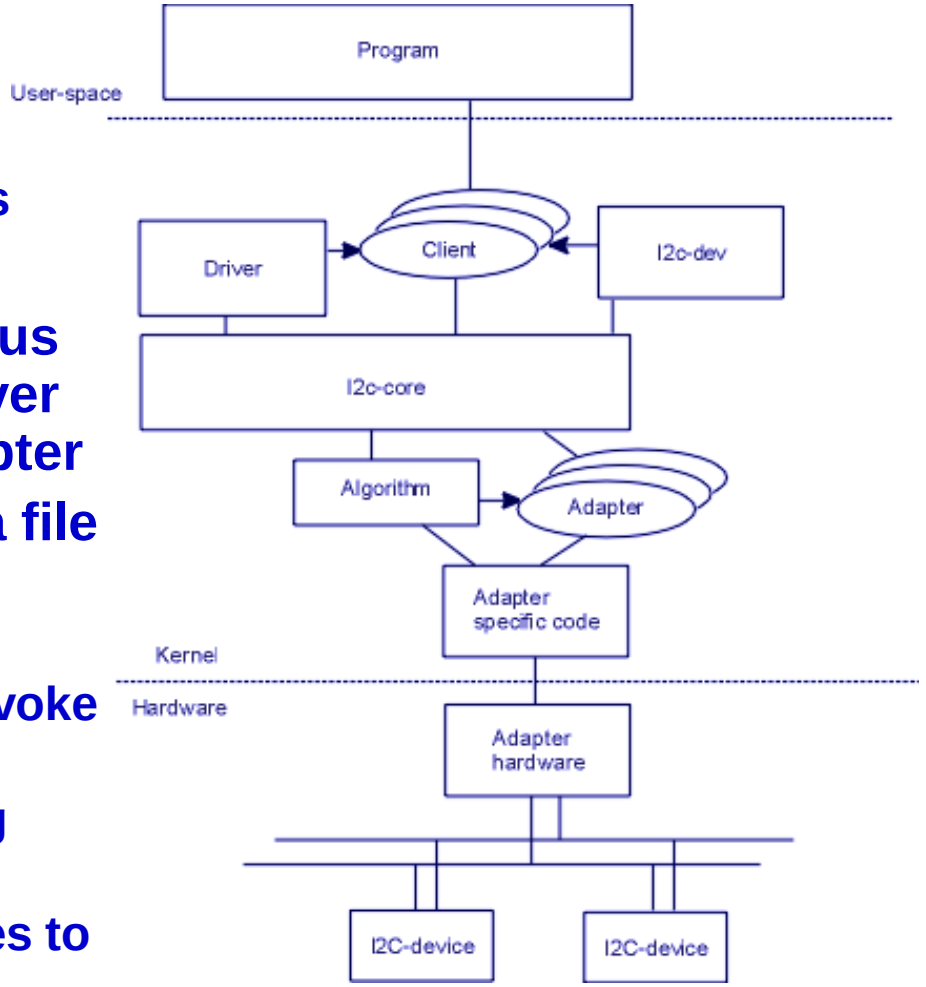
    gpio_set_value(desc1, data);

  - **sysfs gpio interfaces, such as**

    gpiod_export, gpio_unexport, gpiod_set_value, gpio_direction_input

I2C Drivers in Linux

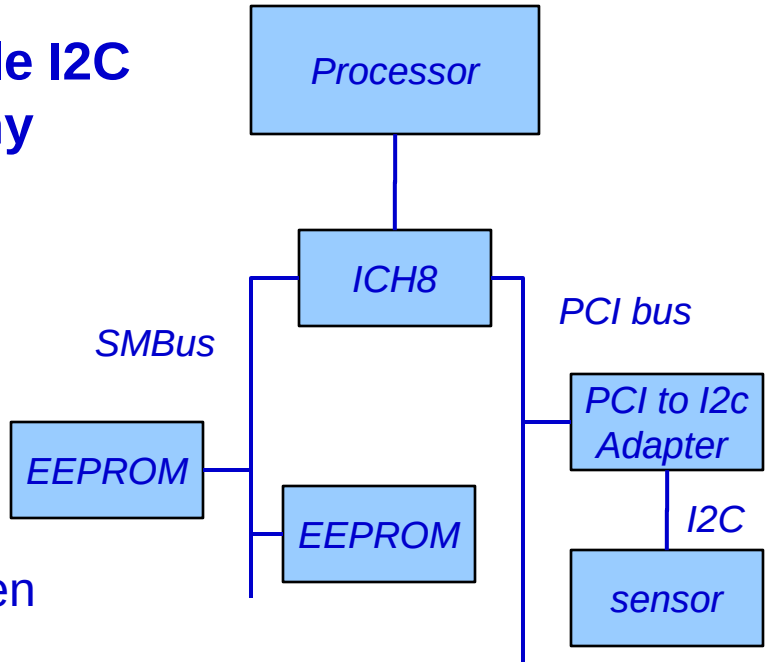
- A driver for I2C bus
  - adapter and algorithm drivers
  - manages I2C bus transactions
- Drivers for I2C devices
- A client has the device's I2C bus address and a pointer to a driver which is attached with an adapter
- When a user program issues a file operation that needs an I2C transaction
  - i2C_transfer (i2C-core.c) to invoke adap_algo_master_xfer
  - command or data is in an msg array
  - the adapter issues reads/writes to hardware I/O addresses.



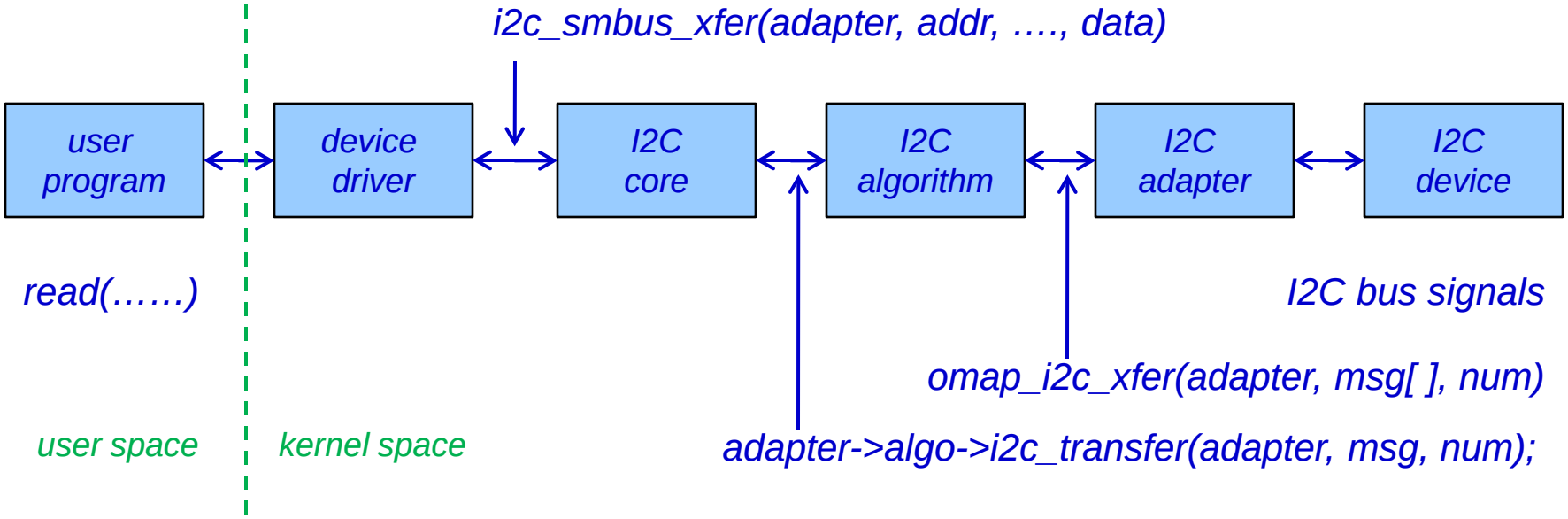
(https://i2c.wiki.kernel.org/index.php/Driver_Architecture)

I2C and SMBus

- **In general, a system can have multiple I2C buses via different adapters and many I2C devices**
- **2-wire synchronous serial buses**
  - Master and slave, addressable
- **I2C bus and SMBus**
  - compatible with each other.
- **Differences**
  - Timeout (in SMBus, reset interfaces when clock is low forlonger than 35ms))
  - Maximum clock speed: 100MHz(Smbus) but I2C bus has both 400kHz and 3.4MHz versions.
  - Logic level: 1: 3V in I2C and 2.1V in SMBus
  - General call and alert response.



Example of Accessing I2C/SMBus Devices




```
// for each i2c device
struct i2c_client {
        unsigned short  flags;
        unsigned short  addr;
        char  name[I2C_NAME_SIZE];
        struct i2c_adapter *  adapter;
        struct i2c_driver *  driver;
        struct device  dev;
        int  irq;
        struct list_head  list;
        struct completion  released;
};
```