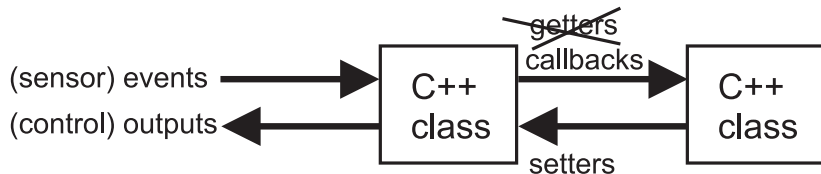


# Realtime Embedded Coding: recap

Bernd Porr

# Callbacks



A realtime system with two C++ classes. Communication between classes is achieved with callbacks (not getters) for incoming events and setters to send out control events. The control output itself receives its timing from the events so that the loop is traversed as quickly as possible.

## C++ callback interface

Callback interface:

```
class LSM9DS1callback {  
public:  
    virtual void hasSample(LSM9DS1Sample sample) = 0;  
};
```

C++ driver class:

```
void LSM9DS1::dataReady() {  
    LSM9DS1Sample sample;  
    // fills the sample struct with data  
    // ...  
    lsm9ds1Callback->hasSample(sample);  
}
```

C++ driver callback registration:

```
void LSM9DS1::registerCallback(LSM9DS1callback* cb);
```

## Merging C++ driver class and callback interface

Instead of creating a separate class containing the callback you can also add the callback straight to the device driver class.

```
class ADS1115rpi {  
    ...  
    virtual void hasSample(float sample) = 0;  
    ...  
};
```

This forces the client to implement the callback to be able to use the class. This creates a very safe environment as all dependencies are set at compile time and the abstract nature of the base class makes clear what needs to be implemented. See [https://github.com/berndporr/rpi\\_ads1115](https://github.com/berndporr/rpi_ads1115) for a complete example.

## Event timing: GPIO events

```
class mySensorClass {  
    static void gpioISR(int g, int l, uint32_t, void* usr)  
        ...  
}
```

is registered with pigpio:

```
gpioSetISRFuncEx(24,RISING_EDGE,ISR_TIMEOUT,gpioISR,  
                (void*)this);
```

The callback registered will then be `this->dataReady()`.

```
class LSM9DS1 {  
    void dataReady();  
    static void gpioISR(int gpio, int level, uint32_t tick,  
    {  
        ((LSM9DS1*)userdata)->dataReady();  
    }  
};
```

## Event timing: blocking I/O

Thread workers with endless loops are often used in conjunction with blocking I/O which provide the timing:

```
void run() {  
    running = true;  
    while (running) {  
        read(buffer); // blocking  
        doCallback(buffer); // hand data to client  
    }  
}
```

## Event timing: select()

Non-blocking I/O and select() which waits till data has become available.

```
FD_ZERO(&rdset);
FD_SET(fileno,&rdset);
struct timeval timeout;
timeout.tv_sec = 0;
timeout.tv_usec = 500000;
int ret = select(fileno+1,&rdset,NULL,NULL,&timeout);
if (ret < 0) return ret;
// non-blocking I/O read
ret = read(fileno,buffer,bytes_per_sample * n_chan);
```

## Event timing: poll()

poll() is similar to select() but has less temporal resolution (ms) to wake up a thread. Here used to wake up a thread after a GPIO pin has been triggered in /sys:

```
int SysGPIO::gpio_poll(int gpio_fd, int timeout) const
{
    struct pollfd fdset[1] = {};
    int nfd = 1;
    char buf[MAX_BUF] = { 0 };
    fdset[0].fd = gpio_fd;
    fdset[0].events = POLLPRI;

    int rc = poll(fdset, nfd, timeout);

    if (fdset[0].revents & POLLPRI) {
        (void)read(fdset[0].fd, buf, MAX_BUF);
    }
    return rc;
}
```



## Timing with Linux/pigpio timers

As a *last resort* one can use a timer. Similar to threads one can create timers which are then called at certain intervals. As with threads timers should be *hidden* within a C++ class as *private* members which then trigger *public callbacks* via C++ callback mechanisms as described above.

Generally it's *not recommended* to use timers for anything which needs to be reliably sampled, for example ADC converters or sensors with sampling rates higher than a few Hz. On the raspberry PI use the pigpio library and its timer callbacks — if needed at all.

## How does an event driven main() look like?

```
int main() {  
    Camera camera;  
    AI ai;  
    GUI gui;  
  
    gui.register(&ai);  
    ai.register(&camera);  
  
    camera.start();  
    ai.start();  
  
    gui.exec(); // blocking till user shuts it down  
  
    ai.stop();  
    camera.stop();  
    return 0;  
}
```