

Figure 1: Real-time Linux executes real-time tasks

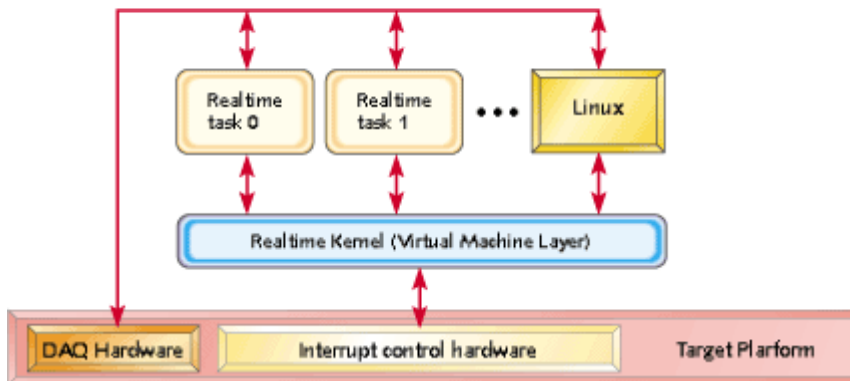


Figure 2: Dual data-acquisition driver interfaces

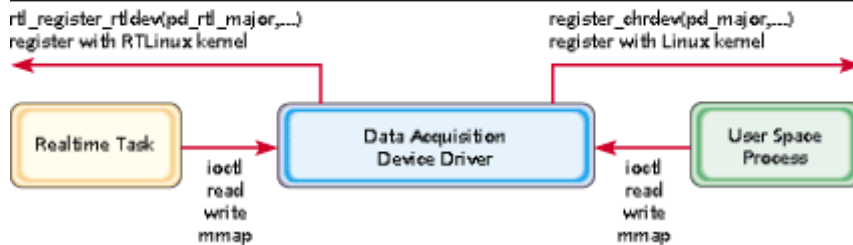
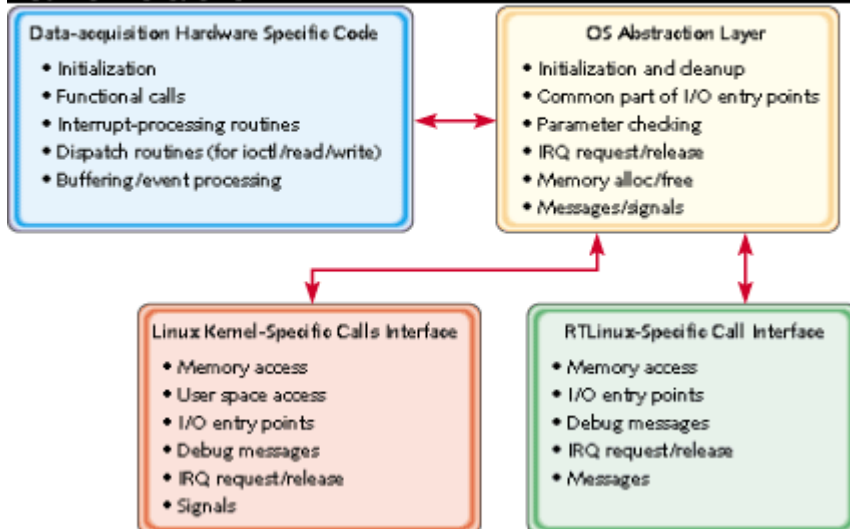


Figure 3: OSAL driver design allows you to run the same driver for user-space and real-time tasks



Listing 1: Main loop

```
while (alive)
{
  get_sensor_data(); // read one or more sensors
  compute_control(); // calculate control parameters based on
                    // incoming data
  control_device(); // initiate control activity
                    // read next group of sensors...calculate...control
}
```

Listing 2: makefile.pp_flip

```
# Makefile.pp_flip
all: pp_flip.o

RTLINUX = /usr/src/linux # the path to the rt-linux kernel
INCLUDE = ${RTLINUX}/include
CFLAGS = -O2 -Wall

pp_flip.o: pp_flip.c
  gcc -I${INCLUDE} -I/usr/include/rtlinux ${CFLAGS} -D__KERNEL__ -D__RT__
  - DMODULE -c pp_flip.c

clean:
  rm -f pp_flip.o
```

Listing 3: Includes and defines for pp_flip.c

```
#include <linux/module.h>
#include <linux/kernel.h>
#include <linux/version.h>
#include <linux/errno.h>
#include <rtlinux/rtl_sched.h>
#include <asm/io.h>

#define LPT1_DATA 0x378 // parallel port 1 data
#define FRQ 1000 // thread period in Hz...
#define FRAME_PERIOD_NS ((hrtime_t)((1.0/FRQ) * 1000000000.0)) // ...and in ns
```

Listing 4: pp_flip.c

```
pthread_t pp_thread;
// our periodic thread
void *pp_thread_ep(void *rate) {
    static int nState = 0;

    // make this realtime thread periodic
    pthread_make_periodic_np(pthread_self(),gethrtime(),FRAME_PERIOD_NS);
    // this loop wakes up once per period
    while (1)
    {
        if (nState) outb(nState--, LPT1_DATA); else outb(nState++,LPT1_DATA);
        // wait until next period of time
        pthread_wait_np();
    }
}

int init_module(void) {
    pthread_attr_t attrib;
    struct sched_param sched_param;
    // output string to /var/log/kern.log
    printk("init_module pp_flip\n");

    // prepare periodic thread for creation
    // initialize thread attributes
    sched_param.sched_priority = sched_get_priority_max(SCHED_FIFO);
    // obtain highest priority
    pthread_attr_init(&attrib);
    // set our priority
    pthread_attr_setschedparam(&attrib, &sched_param);

    // and finally create the thread
    pthread_create(&pp_thread, &attrib, pp_thread_ep, (void *)0);
    return 0;
}

int cleanup_module(void) {
    printk("cleanup_module pp_flip\n");
    pthread_delete_np(pp_thread); // kill the thread
    return 0;
}
```

Listing 5: Registering a driver for use by real-time and non real-time tasks

```
// Linux driver operations
static struct file_operations ln_pd_fops =
{
  read: ln_pd_read,
  write: ln_pd_write,
  ... other "magic" functions
};

// RTLinux driver operations
static struct rtl_file_operations rtl_pd_fops = {
  NULL,
  rtl_pd_read,
  rtl_pd_write,
  ... other "magic" functions
};

// register Linux driver...
if (register_chrdev(PD_LN_MAJOR, "pdaq", &ln_pd_fops))
{ handle errors... }
// ...and RTLinux driver
if (rtl_register_chrdev(PD_RT_MAJOR, "pdaq", &rtl_pd_fops))
{ handle errors... }
```

Listing 6: Driver's RTLinux and Linux entry points for read()

```
// read entry point registered by rtl_register_rtldev()
static ssize_t rtl_pd_read(struct rtl_file *filp, char *buf,
    size_t count, loff_t* ppos)
{
    u32 minor = RTL_MINOR_FROM_FILEPTR(filp);
    board = minor / PD_MINOR_RANGE;
    subsystem = minor % PD_MINOR_RANGE;
    return pd_read(minor, buf, count);
}

// read entry point registered by register_chrdev()
static ssize_t ln_pd_read(struct file *filp, char *buf,
    size_t len, loff_t* ppos)
{
    u32 minor = MINOR(inode->i_rdev);
    return pd_read(minor, buf, count);
}

// main read() function
int pd_read(u32 minor, char *inbuf, size_t count)
{
    u32 board = minor / PD_MINOR_RANGE;
    u32 subsystem = minor % PD_MINOR_RANGE;
    // process read request to particular board and subsystem
    ...
}
```

Listing 7: Different calls for user and kernel spaces
unsigned long osal_memcpy32(u32* to, u32* from, u32 len)

```
{
#ifdef _NO_USERSPACE
    return (u32)memcpy(to, from, len);
#else
    return copy_from_user(to, from, len);
#endif
}
```