Operating Systems

Devices

Irvin Aloise
ialoise@diag.uniroma1.it

Department of Computer Control and Management Engineering
Sapienza University of Rome

Devices in Linux (1)

Computers have to interact with many different devices

- Storage devices (e.g. disks)
- Transmission devices (e.g. network, Bluetooth, ...)
- IO devices (e.g. keyboard, joystick, audio and video capture, ...)

Devices in Linux (2)

How do we interact with all those guys?

We stick to the Linux mantra that says:

“Everything is a file”

DMA (1)

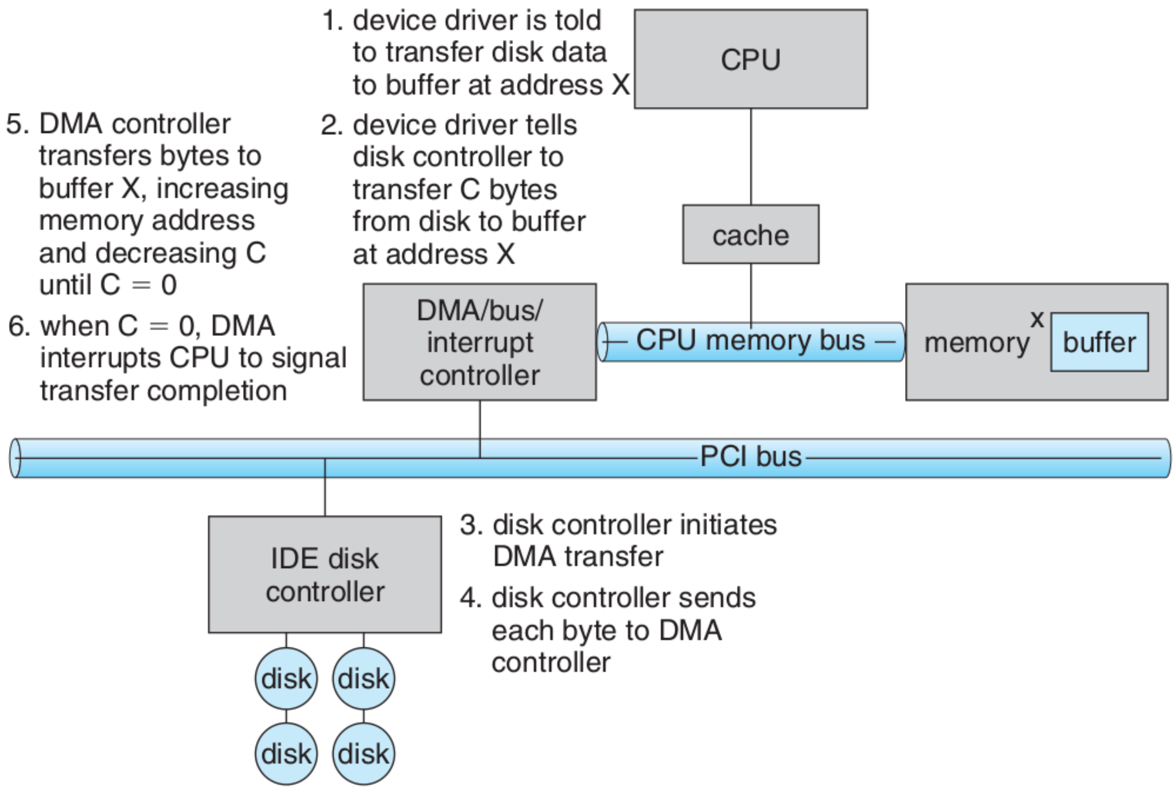
Some devices have to transfer big quantities of data all togheter.

How to do this without bothering the CPU too much?

Direct Memory Access

DMA (2)

Basic concept: the device puts its data in a reserved memory area and generates a **single interrupt** – only when the transfer is *completed*.



Study Case: Joystick

Joystick is relatively easy to handle in Linux

- Most of joysticks are natively supported

- The joystick is a *device*

```
int fd = open ("/dev/input/js0", O_RDONLY);
```

- Joystick reading is event-based

```
struct js_event e;
read (fd, &e, sizeof(e)); // do it forever
```

Study Case: Serial Port (1)

Dealing with a **serial** device requires to setup specific parameters relative to this type of communication.

- Serial is seen as a file
- Linux provides APIs to deal with such class of devices – called `termios`
- `termios` allow us to setup communication parameters (e.g. comm speed)
- Once we setup the parameters, we can interact with it as a simple file – using `read` and `write`

Study Case: Serial Port (2)

How to deal with a serial in practice

1) Open serial and get a file descriptor

```
int fd = open (name, O_RDWR | O_NOCTTY | O_SYNC );
if (fd < 0) {
  printf ("error %d opening serial, fd %d\n", errno, fd);
}
```

2) Setup parameters using termios

```
int serial_set_interface_attribs(int fd, int speed, int parity) {
  struct termios tty;
  memset (&tty, 0, sizeof tty);
  if (tcgetattr (fd, &tty) != 0) {
    printf ("error %d from tcgetattr", errno);
    return -1;
  }
  switch (speed){
  case 57600:
    speed=B57600;
    break;
  case 115200:
    speed=B115200;
    break;
  default:
    printf("cannot sed baudrate %d\n", speed);
    return -1;
  }
  cfsetospeed (&tty, speed);
  cfsetispeed (&tty, speed);
  cfmakeraw(&tty);
  // enable reading
  tty.c_cflag &= ~(PARENB | PARODD);              // shut off parity
  tty.c_cflag |= parity;
  tty.c_cflag = (tty.c_cflag & ~CSIZE) | CS8;     // 8-bit chars

  if (tcsetattr (fd, TCSANOW, &tty) != 0) {
    printf ("error %d from tcsetattr", errno);
    return -1;
  }
  return 0;
}
```

3) Read/write

```
int n=read (cl->fd, &c, 1);
ssize_t res = write(cl->fd,&c,1);
```

4) Close serial

```
close(cl->fd);
```

Study Case: Camera (1)

Cameras require to transfer many bytes all together – i.e. images – and have slightly more complex drivers to deal with.

- Obviously it is seen as a *file :)*
- Linux provides APIs to control camera through V4L (now V4L2) library
- DMA is preferred (used together with `mmap`)
- Device must be probed to understand how it works and its capabilities – through the `ioctl` black magic

Study Case: Camera (2)

Generic workflow to acquire raw images using V4L2.

1) Open the camera as a file
2) Query the device to gather its property
3) Setup DMA and buffers
4) Request buffers from device
5) Capture frames and save them on disk
6) Deallocate memory and close device

Study Case: Camera (3)

```
int main(int argc, char** argv)
{
  if (argc != 2) {
    printf("usage: <executable> <number_of_frames> - eg ./camera_capture 100\n");
    return -1;
  }

  const int num_frames = atoi(argv[1]);
  if (num_frames < 0) {
    printf("error, invalid number of frames - it must be positive :)\n");
    printf("usage: <executable> <number_of_frames> - eg ./camera_capture 100\n");
    return -1;
  }

  camera_t* camera = camera_open("/dev/video0", 640, 480);
  camera_init(camera);
  camera_start(camera);

  struct timeval timeout;
  timeout.tv_sec = 1;
  timeout.tv_usec = 0;
  char image_name[1024];
  for (int i = 0; i < num_frames; ++i) {
    if (camera_frame(camera, timeout)>0) {
      sprintf(image_name, "image-%05d.pgm", i);
      printf("acquiring frame %d\n", i);
      savePGM(camera, image_name);
    }
  }
  camera_frame(camera, timeout);

  camera_stop(camera);
  camera_finish(camera);
  camera_close(camera);
  return 0;
}
```