Linux DVB API Version 4

http://www.linuxdvb.org

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Contents

1 Introduction

DVB is the abbreviation for "Digital Video Broadcasting" and is an industry project managed by the Digital Video Broadcasting Project.

It's an an industry-led consortium of broadcasters, manufacturers, network operators, software developers, regulatory bodies and others that are interesting in standards for the delivery of any digitized informations to the home.

LinuxTV is a vendor independent, non-profit Linux project that works on a standardized Linux DVB API since 2000. The Linux DVB API Version 3 is included in the 2.6 kernel series and is very popular on PC systems mostly in Europe and Australia.

It's used by lots of open-source projects and various commercial set-top-boxes (STB) on different hardware platforms.

Unfortunately, the Linux DVB API Version 3 has some design flaws that make it uncomfortable to use on embedded systems and set-top-boxes. Some of the hardware capabilities of modern chipsets cannot be used to the full extend and memory and processing power are wasted unnecessarily.

The Linux DVB API Version 4 honours the developments on the field of modern DVB chipsets and solves the existing problem by defining a complete new API. Porting old applications is fairly easy because the v3 API is a complete subset of the new v4 API.

It's inevitable to have some knowledge in the area of digital video broadcasting (DVB) and at least part I of the MPEG2 specification ISO/IEC 13818 (aka ITU-T H.222) to understand the Linux DVB API Version 4.

Most of the DVB standards documents are available for free from http://www.dvb.org or http://www.etsi.org.

DVB is based on MPEG2 transport streams, just like ATSC (USA) and ISDB (Japan). In theory, Linux DVB API Version 4 can easily be extended to cover these standards, too, but so far nobody has cared enough to provide any proposals.

1.1 Goals

LinuxTV doesn't want to be a complete multimeda framework. Graphics output and sophisticated video scaler handling is handled best by DirectFB. There is no support for arbitrary multimedia data that the hardware cannot process directly. The LinuxTV doesn't

have support for auxillary hardware that is found in typical STBs or IDTVs, like smartcard interfaces.

LinuxTV is a hardware independent, kernel level only driver framework to control digital TV hardware easily and efficiently

The idea is to make the life of both software and hardware developers easier and provide a consistent abstraction layer for different hardware.

Software developers can support different hardware platforms easier and make their applications truely hardware independent. The hardware vendors can provide support for their existing products easier and can provide a smooth transition from one chipset generation to the next.

1.2 Related technologies

"IP-over-DVB" uses techniques like Multi Protocol Encapsulation (MPE) or Ultra Light Encapsulation (ULE) to put IP packets into MPEG2 transport stream packets. The existing DVB infrastructure is used to provide a high bandwitdh network downstream.

"DVB-over-IP" puts MPEG2 transport stream packages into IP packages and uses existing IP infrastructure to transport DVB data. There is currently only an ETSI draft standard available, so currently RTP is used most of the time to ensure low-latency transmisssion.

Of course it's possible to put nearly everthing into MPEG2 transport stream packets. For example hardware vendors can provide a System Software Update (SSU) for their products.

Because of the fact that most hardware can playback MPEG2 program streams and MPEG1 data streams, at least the hardware can theoretically support DVD playback.

1.3 History

In 1998 the Technotrend GmbH develops the still very popular PC DVB card with a full-featured STB processor on it. In 1999 Siemens produces a card based on the Technotrend design and supports the development of the first Linux driver as a diploma thesis.

In 2000 Nokia develops a DVB API and approaches Convergence GmbH to implement this API for the Siemens card. At the same time, the community project LinuxTV is launched to promote the new API, which is sponsored by Convergence until mid 2004.

Nokia shortly after terminates it's efforts and the API is then heavily modified to become more Linux specific. During that time many new drivers are added to the repository by developers from all around the world to support a variety of DVB hardware.

In 2001 the ongoing developments finally result in the Linux DVB API Version 3 which is included into the Linux kernel 2.5.44 in 2002.

In 2003 Convergence and Toshiba Electronics Europe GmbH start the development of the Linux DVB API Version 4 with public discussion of the API features on the linux-dvb mailing list. The reason to create a complete new API was the fact that PCs and embedded platforms are diverging. On PCs, only budgets cards are currently produced, which only provide the full raw transport stream and leave all decoding and processing up to the main CPU. On embedded platforms, however, data is multiplexed by specialized hardware or firmware for direct application use which relieves the main CPU from these tasks. Because of the fact that there is no new "full-featured" PC DVB card in sight, the Linux DVB API Version 4 heads towards highly-integrated embedded STB and Integrated Digital TV (IDTV) systems.

In 2004 the Linux DVB API Version 4 is nearly fully specified and the generic DVB modules and a sample driver for the Siemens card is available.

Today, the LinuxTV project is a community project by DVB enthusiasts and developers interested in Digital TV. It's open, independent and non-profit and hosted on independent servers.

2 Design

The Linux DVB API Version 4 is a means to control digital tv hardware easily and efficiently. It's designed to support PCI/USB DVB extension cards, dedicated set-top-box (STB) chipsets and integrated digital TV (IDTV) solutions. It's a hardware independent driver framework that is available as a kernel level programming interface.

2.1 Present situation

Although the Linux DVB API Version 3 is widespread, in use by applications and well-known to the programmers, it's inevitable to establish a new API to circument some of the major problems the Linux DVB API Version 3 has.

First of all, PCs and embedded platforms are divering. For PCs, new cards are only available as "budget" cards, which means that they only provide the full, raw, unmodified TS to the system and put the burden of handling the data to the main CPU.

On embedded platforms, however, dedicated STB/IDTV chipsets demultiplex the data for direct application use and specialized hardware or firmware on DSPs relieves the main CPU greatly.

There is a new challenge with supporting embedded platforms running Linux and the Linux DVB API Version 4 heads towards highly-integrated embedded STB and IDTV systems.

2.2 Linux DVB API Version 3 problems

The Linux DVB API Version 3 was focussed on the popular Siemens PCI DVB card. Due to the pragmatic evolution of the API, there are namespace inconsitencies and inconsitent remains of things that really don't belong into the API, like ad-hoc DVD subtitle support or a very limited OSD API design.

There is a superfluous internal DVB kernel layer, because the initial idea was to have the possibility to provide a socket based interface to the DVB core in the future, which of course never happened.

The Linux DVB API Version 3 has very limited support for modern hardware. There is no explicit support for multiple frontends, video and audio decoders and no possibility to make explicit source-sink connections. Current implementations are highly hardware dependent.

There is no support for important features like special recording hardware and event logging facilities, that are provided by modern hardware.

The main drawnback of the Linux DVB API Version 3, however, is that all data transfers go through memory ringbuffers, which means that there is no support for zero-copy DMA. On PCs this does not matter much, but on embedded platforms, this is a major burden to the main CPU.

Because of the architectual problems of the core, the inconsitency of the API and the lack of zero-copy DMA it's not possible to simply extend the existing API. A complete new design is inevitable.

2.3 Linux DVB API Version 3 vs.Version 4

From the userspace perspective, there are not many differences between the Linux DVB API Version 4 and the Linux DVB API Version 3. Both are using a Linux/Posix character device interface under the /dev/dvb/adapter... tree. They use the standard Unix system calls like `open()`, `read()` and `ioctl()` to achieve cirtain action on the device. Most userspace programs can be easily ported to the Linux DVB API Version 4, because the core features that have been in the Linux DVB API Version 4 were only slightly changed. To use the new features like zero-copy DMA via the `mmap()` system call, however, bigger changes are necessary.

2.4 Design overview

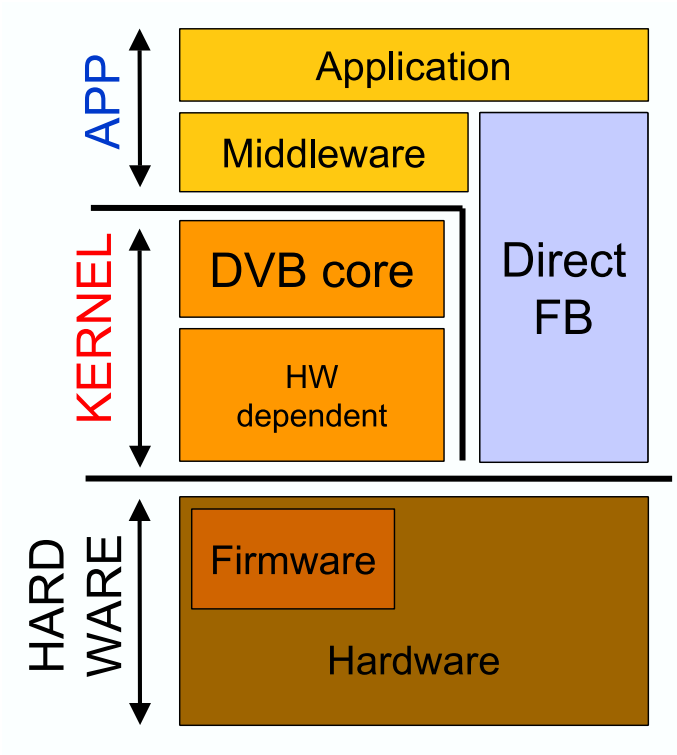

Figure 2.1: foo1

3 Miscellaneous

3.1 Common error return codes

IOCTLs have some common error return codes:

- `EBADF`: the device wasn't opened in the right mode
- `ENOMEM`: out of kernel memory

4 Frontend API

A frontend usually provides the raw transport stream internally to a demux device.

4.1 Device informations

```
/*! describes the type of the frontend */
enum dvb_fe_type {
  DVB_FE_DVB_S = (1 << 0), /* DVB-S frontend with QPSK modulation */
  DVB_FE_DVB_C = (1 << 1), /* DVB-C frontend with QAM modulation */
  DVB_FE_DVB_T = (1 << 2), /* DVB-T frontend with OFDM modulation */
};


/*! describes the supported forward error correction code rates */
enum dvb_fe_code_rate {
  DVB_FE_FEC_NONE = (1 << 0),
  DVB_FE_FEC_1_2  = (1 << 1),
  DVB_FE_FEC_2_3  = (1 << 2),
  DVB_FE_FEC_3_4  = (1 << 3),
  DVB_FE_FEC_4_5  = (1 << 4),
  DVB_FE_FEC_5_6  = (1 << 5),
  DVB_FE_FEC_6_7  = (1 << 6),
  DVB_FE_FEC_7_8  = (1 << 7),
  DVB_FE_FEC_8_9  = (1 << 8),
  DVB_FE_FEC_AUTO = (1 << 9),
};


/*! describes the supported modulation types */
enum dvb_fe_modulation {
  DVB_FE_QPSK     = (1 << 0),
  DVB_FE_QAM_16   = (1 << 1),
  DVB_FE_QAM_32   = (1 << 2),
  DVB_FE_QAM_64   = (1 << 3),
  DVB_FE_QAM_128  = (1 << 4),
  DVB_FE_QAM_256  = (1 << 5),
  DVB_FE_QAM_AUTO = (1 << 6),
};


/*! describes common supported frontend capabilities */
enum dvb_fe_common_cap {
  DVB_FE_CAN_INVERSION_AUTO   = (1 << 0), /* fixme */
  DVB_FE_CAN_RECOVER          = (1 << 1), /* frontend can recover from a cable unplug automatically */
  DVB_FE_CAN_MUTE_TS          = (1 << 2), /* frontend can stop spurious TS data output */
  DVB_FE_SUP_HIGH_LNB_VOLTAGE = (1 << 3), /* fixme, frontend can deliver higher lnb voltages */
};
```

```
/*! describes other, type dependend frontend capabilities */
enum dvb_fe_other_cap {
  DVB_FE_CAN_TRANSMISSION_MODE_AUTO = (1 << 0), /* fixme (DVB-T specific) */
  DVB_FE_CAN_BANDWIDTH_AUTO         = (1 << 1), /* fixme (DVB-T specific) */
  DVB_FE_CAN_GUARD_INTERVAL_AUTO    = (1 << 2), /* fixme (DVB-T specific) */
  DVB_FE_CAN_HIERARCHY_AUTO         = (1 << 3), /* fixme (DVB-T specific) */
};


/*! is used to query general informations about the frontend. */
struct dvb_frontend_info {
  char             name[128];             /* brand name */
  enum dvb_fe_type type;                  /* frontend type */
  uint32_t         frequency_min;         /* minium tuning frequency, fixme unit? */
  uint32_t         frequency_max;         /* maximum tuning frequency, fixme unit?  */
  uint32_t         frequency_stepsize;    /* fixme */
  uint32_t         frequency_tolerance;   /* fixme */
  uint32_t         symbol_rate_min;       /* minium tuning frequency, fixme unit? */
  uint32_t         symbol_rate_max;       /* maximum tuning frequency, fixme unit? */
  uint32_t         symbol_rate_tolerance; /* in ppm, fixme */
  uint32_t         notifier_delay;        /* in ms, fixme */

  enum dvb_fe_code_rate  caps_fec;        /* supported fecs */
  enum dvb_fe_modulation caps_modulation; /* supported modulations */
  enum dvb_fe_common_cap caps_common;     /* supported common capabilities */
  enum dvb_fe_other_cap  caps_other;       /* supported other capabilities*/
};


/*! get basic informations about a frontend device */
#define DVB_FE_GET_INFO               _IOR(DVB_IOCTL_BASE,  0x00, struct dvb_frontend_info)
```

4.2 SEC control

pre-DiSEqC compatibility satellite equipment control (SEC) commands

```
/*! describes the available voltage settings */
enum dvb_sec_voltage {
  DVB_SEC_VOLTAGE_13,
  DVB_SEC_VOLTAGE_18,
  DVB_SEC_VOLTAGE_OFF
};


/*! sets desired voltage */
#define DVB_FE_SEC_SET_VOLTAGE         _IOW(DVB_IOCTL_BASE, 0x06, enum dvb_sec_voltage)


/*! describes the available tone settings */
enum dvb_sec_tone_mode {
  DVB_SEC_TONE_ON,
  DVB_SEC_TONE_OFF
};


/*! sets desired tone setting */
#define DVB_FE_SEC_SET_TONE            _IOW(DVB_IOCTL_BASE, 0x05, enum dvb_sec_tone_mode)
```

```
/*! describes the available burst settings */
enum dvb_sec_tone_burst {
  DVB_SEC_BURST_A,
  DVB_SEC_BURST_B
};


/*! sents desired burst */
#define DVB_FE_SEC_SEND_BURST          _IOW(DVB_IOCTL_BASE, 0x04, enum dvb_sec_tone_burst)


/*! enables high lnb voltage */
#define DVB_FE_ENABLE_HIGH_LNB_VOLTAGE _IOW(DVB_IOCTL_BASE, 0x07, unsigned int)
```

4.3 DiSEqC commands

```
/*! fixme */
#define DVB_FE_DISEQC_RESET_OVERLOAD   _IOW(DVB_IOCTL_BASE, 0x01, unsigned int)


/*! check out the DiSEqC bus spec available on http://www.eutelsat.org/ for
 the meaning of this struct */
struct dvb_diseqc_master_cmd {
  uint8_t msg [6];  /* { framing, address, command, data [3] } */
  uint8_t msg_len;  /* valid values are 3...6  */
};


/*! sends a DiSEqC message */
#define DVB_FE_DISEQC_SEND_MASTER_CMD  _IOW(DVB_IOCTL_BASE,  0x02, struct dvb_diseqc_master_cmd)


/*! check out the DiSEqC bus spec available on http://www.eutelsat.org/ for
 the meaning of this struct */
struct dvb_diseqc_slave_reply {
  uint8_t msg [4];  /* { framing, data [3] } */
  uint8_t msg_len;  /* valid values are 0...4, 0 means no msg  */
  int     timeout;  /* return from ioctl after timeout ms with  errorcode when no message was received */
};


/*! receives a DiSEqC message from a slave */
#define DVB_FE_DISEQC_RECV_SLAVE_REPLY _IOR(DVB_IOCTL_BASE,  0x03, struct dvb_diseqc_slave_reply)
```

4.4 frontend status

```
/*! describes the current frontend status */
enum dvb_fe_status {
  DVB_FE_HAS_SIGNAL     = (1 << 0),   /* found something above the noise level */
  DVB_FE_HAS_CARRIER    = (1 << 1),   /* found a DVB signal  */
  DVB_FE_HAS_VITERBI    = (1 << 2),   /* FEC is stable  */
  DVB_FE_HAS_SYNC       = (1 << 3),   /* found sync bytes  */
  DVB_FE_HAS_LOCK       = (1 << 4),   /* everything's working */
  DVB_FE_TIMEDOUT       = (1 << 5),   /* no lock within the last ~2 seconds */
  DVB_FE_REINIT         = (1 << 6),   /* frontend was reinitialized, application is recommended to reset DiSEqC, tone a
};


/*! retrieves the current frontend status */
#define DVB_FE_READ_STATUS             _IOR(DVB_IOCTL_BASE,  0x08, enum dvb_fe_status)
```

```
/* describes some frontend statistical informations, if available by the frontend */
enum dvb_fe_statistics_avail {
  DVB_FE_BER                = (1 << 0), /* bit error rate */
  DVB_FE_SIGNAL_STRENGTH    = (1 << 1), /* signal strength */
  DVB_FE_SNR                = (1 << 2), /* signal to noise ratio */
  DVB_FE_UNCORRECTED_BLOCKS = (1 << 3), /* number of uncorrected blocks */
};


/*! is used to retrive statistical informations from the frontend */
struct dvb_fe_statistics {
  enum dvb_fe_statistics_avail avail; /* describes the available informations */
  uint32_t ber;                       /* bit error rate, if available */
  uint16_t signal_strength;           /* signal strength, if available */
  uint16_t snr;                       /* signal to noise ratio, if available */
  uint32_t uncorrected_blocks;        /* number of uncorrected blocks, if available */
};


/*! retrives statistical informations from the frontend. the informations are reset in the
 frontend after the data has been retrieved. */
#define DVB_FE_READ_STATIISTICS        _IOR(DVB_IOCTL_BASE,  0x09, struct dvb_fe_statistics)
```

4.5 configuration and tuning

```
/*! describes the spectral inversion setting of the frontend */
enum dvb_fe_spectral_inversion {
  DVB_FE_INVERSION_OFF,
  DVB_FE_INVERSION_ON,
  DVB_FE_INVERSION_AUTO
};


/*! tuning parameters for DVB-S frontends */
struct dvb_dvb_s_parameters {
  uint32_t               symbol_rate;  /* symbol rate in Symbols per second */
  enum dvb_fe_code_rate  fec_inner;    /* forward error correction (see above) */
};


/*! tuning parameters for DVB-C frontends */
struct dvb_dvb_c_parameters {
  uint32_t                symbol_rate; /* symbol rate in Symbols per second */
  enum dvb_fe_code_rate   fec_inner;   /* forward error correction (see above) */
  enum dvb_fe_modulation  modulation;  /* modulation type (see above) */
};


/*! fixme */
enum dvb_fe_bandwidth {
  DVB_BANDWIDTH_8_MHZ,
  DVB_BANDWIDTH_7_MHZ,
  DVB_BANDWIDTH_6_MHZ,
  DVB_BANDWIDTH_AUTO
};


/*! fixme */
enum dvb_fe_transmit_mode {
  DVB_TRANSMISSION_MODE_2K,
  DVB_TRANSMISSION_MODE_8K,
  DVB_TRANSMISSION_MODE_AUTO
};
```

```
/*! fixme */
enum dvb_fe_guard_interval {
  DVB_GUARD_INTERVAL_1_32,
  DVB_GUARD_INTERVAL_1_16,
  DVB_GUARD_INTERVAL_1_8,
  DVB_GUARD_INTERVAL_1_4,
  DVB_GUARD_INTERVAL_AUTO
};


/*! fixme */
enum dvb_fe_hierarchy {
  DVB_HIERARCHY_NONE,
  DVB_HIERARCHY_1,
  DVB_HIERARCHY_2,
  DVB_HIERARCHY_4,
  DVB_HIERARCHY_AUTO
};


/*! tuning parameters for DVB-T frontends */
struct dvb_dvb_t_parameters {
  enum dvb_fe_bandwidth      bandwidth;              /* fixme */
  enum dvb_fe_code_rate      code_rate_HP;           /* high priority stream code rate */
  enum dvb_fe_code_rate      code_rate_LP;           /* low priority stream code rate */
  enum dvb_fe_modulation     constellation;          /* modulation type (see above) */
  enum dvb_fe_transmit_mode  transmission_mode;      /* fixme */
  enum dvb_fe_guard_interval guard_interval;         /* fixme */
  enum dvb_fe_hierarchy      hierarchy_information;  /* fixme */
};


/*! is used for tuning a frontend */
struct dvb_frontend_parameters {
  uint32_t frequency;                        /* frequency in 100 Hz (absolute for DVB-C/DVB-T, intermediate DVB-S) */
  enum dvb_fe_spectral_inversion inversion;  /* spectral inversion setting */
  union {
    struct dvb_dvb_s_parameters dvb_s; /* if frontend is DVB-S */
    struct dvb_dvb_c_parameters dvb_c; /* if frontend is DVB-C */
    struct dvb_dvb_t_parameters dvb_t; /* if frontend is DVB-T */
  } u; /* tuning parameters */
};


/*! tunes a frontend using the specified tuning parameters */
#define DVB_FE_SET_FRONTEND            _IOW(DVB_IOCTL_BASE,  0x0d, struct dvb_frontend_parameters)


/*! retrieves the current tuning parameters fromt the frontend */
#define DVB_FE_GET_FRONTEND            _IOR(DVB_IOCTL_BASE,  0x0e, struct dvb_frontend_parameters)
```

4.6 event handling

```
/*! describes a frontend event */
struct dvb_frontend_event {
  enum dvb_fe_status status;                 /* bitfield */
  struct dvb_frontend_parameters parameters; /* tuning parameters at the time the event happened */
};


/*! retrieves the latest tuning event from the frontend, blocks if device wasn't opened with O_NONBLOCK */
#define DVB_FE_GET_EVENT               _IOR(DVB_IOCTL_BASE,  0x0f, struct dvb_frontend_event)
```

5 Memory input API

A memory input accepts a raw data stream (TS, PS or PES) from userspace and internally routes it to a demux device.

5.1 Device informations

```
/*! is used to query general informations about the memory input. */
struct dvb_memory_info {
  char name[128];                 /* descriptive device name */
  enum dvb_source_format formats; /* supported formats */
};

/*! get basic informations about a memory input */
#define DVB_MEMORY_GET_INFO               _IOR(DVB_IOCTL_BASE, 0x80, struct dvb_memory_info)
```

5.2 Configuration

```
/*! is used for the configuration of a memory input */
struct dvb_memory_configuration {
  /* in */
  enum dvb_source_format format;    /* chosen data format */
  size_t  size;       /* desired size of buffer */
  size_t  threshold;      /* notification threshold */

  /* out */
  size_t  mmap_size;  /* size of memory area to mmap() */
  size_t  mmap_offset;  /* offset into memory for data */
};

/*! configures a memory input */
#define DVB_MEMORY_SET_CONFIGURATION       _IOWR(DVB_IOCTL_BASE, 0x81, struct dvb_memory_configuration)
```

5.3 Data input

```
/*! is used to provide data to the memory input */
struct dvb_memory_data {
  size_t offset;  /* offset of confirmed data into buffer */
  size_t len; /* length of confirmed data */
};

/*! retrieves a informations about a data area, where new data can be put */
#define DVB_MEMORY_RETRIEVE_DATA_AREA _IOR (DVB_IOCTL_BASE, 0x83, struct dvb_memory_data)

/*! confirms the specified amount of bytes to the memory input for further processing */
#define DVB_MEMORY_CONFIRM_DATA_AREA  _IOWR(DVB_IOCTL_BASE, 0x84, size_t)
```

6 Demux API

A demux offers filtering capabilities on Frontends **??** frontends or memory inputs **??**.

Most hardware can process different inputs in parallel (for example multiple frontends), so each one of these "devices" will be represented by one logical demux device.

Before any filtering can be done, the device input has to be configured on with a separate device open using the `DVB_DMX_SET_SOURCE` ioctl. It depends on the capabilities of the input device and of the demux, which filters are available and how much can be set afterwards.

The different possible filters are:

1. single MPEG-2 TS PID filter
2. MPEG-2 PSI / DVB SI section filters
3. MPEG-2 PS / MPEG-1 system stream / multiplexed PES filters
4. recording filters based on MPEG-2 TS PID filter
5. direct feeding to a hardware decoder device (decoder feed)

Data from the first four filter types is usally written to userspace and processed there. For the fifth filter type, routing of data to hardware decoders is done by passing the file descriptor of the filter to the decoder device's `SET_SOURCE` ioctl.

6.1 Usage policy

Any demux device can only opened once for writing (ie. `O_WRONLY`); use that open to control the input routing via `DVB_DMX_SET_SOURCE`. All filtering opens must be `O_RDONLY`. Opens using the `O_RDWR` permission are not allowed.

6.2 Capabilities

Capabilities are most likely different for each demux device (e.g. only demux2 accepts MPEG-2 PS).

```
/*! the different capabilities that may be supported by the demux device */
enum dvb_demux_capability {
  DVB_DEMUX_CAP_SOURCE_FORMATS,         /* bitfield, source formats the demux can handle  */
  DVB_DEMUX_CAP_NUM_PES_FILTERS,        /* integer, number of available PES filters  */
  DVB_DEMUX_CAP_NUM_AUDIO_FILTERS,      /* integer, number of available audio filters  */
  DVB_DEMUX_CAP_NUM_VIDEO_FILTERS,      /* integer, number of available video filters  */
```

```
  DVB_DEMUX_CAP_NUM_PCR_FILTERS,        /* integer, number of available pcr filters  */
  DVB_DEMUX_CAP_NUM_SECTION_FILTERS,    /* integer, number of available section filters  */
  DVB_DEMUX_CAP_NUM_PID_FILTERS,        /* integer, number of available pid filters */
  DVB_DEMUX_CAP_PID_FILTER_FLAGS,       /* bitfield, supported flags for pid filters  */
  DVB_DEMUX_CAP_NUM_RECORDING_FILTERS,  /* integer, number of available recording filters */
  DVB_DEMUX_CAP_RECORDING_EVENTS,       /* bitfield, supported recording events by recording pid filters  */
  DVB_DEMUX_CAP_RECORDING_TYPES,        /* bitfield, available recording types  */
  DVB_DEMUX_CAP_NUM_DESCR_KEY_PAIRS,    /* integer, number of available descrambling key pairs (fixme, add ref)*/
};



/*! used to query the capabilities of a demux device */
struct dvb_demux_caps {
  enum dvb_demux_capability cap; /* capability to query  */
  unsigned int            val;   /* output value */
};



/*! queries one specific demux capability. A demux device is expected to support
 quering *all* capabilities mentioned above (ie. return 0 if a capability is
 not supported by the hw.

 \retval EINVAL the capability is unknown
 */
#define DVB_DEMUX_GET_CAPS _IOWR(DVB_IOCTL_BASE, 0x20, struct dvb_demux_caps)
```

Return codes:

- EINVAL: the capability is unknown

6.3 Input routing

```
/*! connects the demux to an already opened frontend or memory input through
 the filedescriptor, only works if the device was opened \c O_WRONLY.

 \retval EINVAL the filedescriptor doesn't belong to any DVB device
 \retval ENOSYS the input device doesn't belong to the same adapter as the demux
 */
#define DVB_DEMUX_SET_SOURCE _IOW(DVB_IOCTL_BASE, 0x21, int /* frontend fd */)
```

Return codes:

- EINVAL: the filedescriptor doesn't belong to any DVB device
- ENOSYS: the input device doesn't belong to the same adapter as the demux

connects the demux to an already opened frontend or memory input through the filedescriptor, only works if the device was opened O_WRONLY by means of the fildescriptor. Input facilities include frontend or memory input devices. The demux devices needs to opened with write permissions in order for DVB_DMX_SET_SOURCE to succeed, each demux device can only opened once with write permissions.

6.4 MPEG-2 TS filters

MPEG-2 TS PID filters filter a TS on the PID value only. Many DVB hardwares support three varieties of PID filters:

1. decoder feeds: data is delivered internally to the decoder
2. general purpose data filters: single PID output to memory
3. stream recording filters: output of multiple PIDs to one common memory

6.4.1 Decoder feeds

Most demuxes can be configured to directly deliver (ie. internally in the hardware) specific TS packets to specified hardware decoding facilities (ie. MPEG video or MPEG audio decoders). The demux file descriptor can then be passed to the decoder's SET_SOURCE ioctl, so the decoder actually gets the TS packets.

```
/*! sets a decoder feed filter on this demux open to deliver specific
 TS packets to the decoder (which has already been connected to the
 demux open)

 \retval EBUSY another filter has already been set
 \retval ENODEV the demux device doesn't have any decoder feeds
 \retval EINVAL the decoder_type parameter is invalid
 */
#define DVB_DEMUX_SET_TS_DECODER_FEED _IOW(DVB_IOCTL_BASE, 0x23, uint16_t /* pid */)
```

Return codes:

- `EBUSY`: another filter has already been set
- `ENODEV`: the demux device doesn't have any decoder feeds
- `EINVAL`: the decoder_type parameter is invalid

sets a decoder feed filter on this demux open to deliver specific TS packets to the specified hardware decoding facility.

6.4.2 PID

The output usually goes to a memory buffer and can be retrieved by read(); O_NONBLOCK opens and poll() are fully supported.

```
/*! describes the desired capabilities of a pid filter. */
enum dvb_demux_pid_filter_flags {
  DVB_DEMUX_FULL_TS         = (1 << 0), /* don't filter on a specific pid, output the whole TS */
  DVB_DEMUX_PAYLOAD_ONLY    = (1 << 1), /* only deliver the payload (ie. strip off the TS header) */
  DVB_DEMUX_ADAPTATION_ONLY = (1 << 2), /* only deliver the TS header and any adaptation fields if present */
  DVB_DEMUX_WAIT_FOR_PUSI   = (1 << 3), /* wait for the payload unit start indicator before starting to filter */
  DVB_DEMUX_HIGH_PRIO_ONLY  = (1 << 4), /* only deliver high priority packets on the specified pid */
  DVB_DEMUX_LOW_PRIO_ONLY   = (1 << 5), /* only deliver low priority packets on the specified pid*/
  DVB_DEMUX_OUTPUT_DUPES    = (1 << 6), /* deliver duplicated packets, too (if the hardware delivers them at all) */
  DVB_DEMUX_OUTPUT_ERRPKTS  = (1 << 7), /* deliver erroneous packets, too (if the hardware delivers them at all) */
};
```

describes the desired capabilities of a pid filter. Some of the options are mutually exclusive of course (for example DVB_DMX_PAYLOAD_ONLY and DVB_DMX_ADAPTATION_ONLY) */

```
/*! used to configure a PID filter */
struct dvb_demux_pid_filter {
  uint16_t pid;                          /* PID to filter (unless DVB_DEMUX_FULL_TS is specified for the flags) */
  enum dvb_demux_pid_filter_flags flags; /* special filtering flags */
  uint32_t buffer_size;                  /* in bytes, size of internal buffer */
  uint32_t buffer_threshold;             /* in bytes, notify threshold, must be <= buffer_size */
};
```

is used to set a pid filter on the demux device open. All TS packets with pid PID and matching flags to a memory buffer.

`buffer_size` and `buffer_threshold` are hints to the driver; the real buffer size and threshold can differ and is written back by the driver.

If the DVB_DMX_FULL_TS flag is specified the *pid* value and the other *flags* are irrelevant and the full TS is output.

```
/*! sets a simple pid filter on the demux open, which delivers all TS packets with matching pid to
 a memory buffer

 \retval EBUSY another filter has already been set
 \retval ENODEV the demux device doesn't have any pid filters
 \retval ENOSYS the demux doesn't support the requested dvb_demux_pid_filter_flags
 \retval EINVAL either buffer_size $<$ 188 or buffer_threshold $>$ buffer_size
 \retval E2BIG the buffer size exceeds DVB_MAX_BUFFER_SIZE
 */
#define DVB_DEMUX_SET_PID_FILTER _IOWR(DVB_IOCTL_BASE, 0x24, struct dvb_demux_pid_filter)
```

Return codes:

- `EBUSY`: another filter has already been set
- `ENODEV`: the demux device doesn't have any pid filters
- `ENOSYS`: the demux doesn't support the requested dvb_demux_pid_filter_flags
- `EINVAL`: either buffer_size $<$ 188 or buffer_threshold $>$ buffer_size
- `E2BIG`: the buffer size exceeds DVB_MAX_BUFFER_SIZE

sets a simple pid filter on the demux open, which delivers all TS packets with *pid* to a memory buffer.

6.4.3 Recording

The output of multiple PIDs goes to a common memory buffer. The recording for a number of PIDs can be started and stopped in one atomic operation.

```
/*! describes the desired type of a recording filter */
enum dvb_demux_recording_type {
  DVB_DEMUX_REC_TYPE_SIMPLE_READ   = (1 << 0), /* simple \c read() based recording, no event logging possible */
  DVB_DEMUX_REC_TYPE_BUFFERED      = (1 << 1), /* buffer based recording */
  DVB_DEMUX_REC_TYPE_EVENT_LOGGING = (1 << 2), /* event logging for buffer based recording */
};
```

describes the desired type of a recording filter. DVB_DMX_REC_TYPE_SIMPLE_READ and DVB_DMX_REC_TYPE_EVE are mutually exclusive and Some of the options are mutually exclusive of course DVB_DMX_REC_TYPE_SI and the other types are mutually excluse of course. Specifying DVB_DMX_REC_TYPE_EVENT_LOGGIN without DVB_DMX_REC_TYPE_BUFFERED is not allowed obviously.

```
/*! is used to set a recording filter on a demux device open */
struct dvb_demux_recording_filter {
  /* in */
  enum dvb_demux_recording_type type; /* type of this recording filter */
  size_t  buffer_size;                /* in bytes, size of the buffer to allocate */
  size_t  buffer_threshold;           /* in bytes, notify threshold, must be $<=$ buffer_size */
  /* out, only valid for type $!=$ DVB_DEMUX_REC_TYPE_SIMPLE_READ */
  size_t  mmap_size;                  /* in bytes, size of memory area to mmap() */
  size_t  data_offset;                /* in bytes, offset into mmap()ed memory for data buffer */
  size_t  log_offset;                 /* in bytes, offset into mmap()ed memory for event logging buffer */
};
```

buffer_size and *buffer_threshold* are hints to the driver; the real buffer size and threshold can differ and is written back by the driver. *mmap_size* and *data_offset* are returned by the driver and are only valid if 0! = (*type*& DVB_DMX_REC_TYPE_BUFFERED). *log_offset* is returned by the driver and is only valid if 0! = (*type*&DVB_DMX_REC_TYPE_EVENT_LOGGING).

```
/*! describes the desired recording events which should be written to the event log */
enum dvb_demux_rec_event {
  DVB_DEMUX_REC_EVENT_NONE                  = 0,         /* none of the events below */
  DVB_DEMUX_REC_EVENT_PUSI                  = (1 <<  0), /* the payload unit start indicator is set */
  DVB_DEMUX_REC_EVENT_TEI                   = (1 <<  1), /* a discontinuity in the PCR has occured */
  DVB_DEMUX_REC_EVENT_DISCONT_INDICATOR     = (1 <<  2), /* a discontinuity in the PCR has occured */
  DVB_DEMUX_REC_EVENT_RANDOM_ACCESS         = (1 <<  3), /* this TS packet is a valid location from which to decode */
  DVB_DEMUX_REC_EVENT_ESPI                  = (1 <<  4), /* this is a high priority packet for this PID stream */
  DVB_DEMUX_REC_EVENT_PCR                   = (1 <<  5), /* this packet contains a pcr */
  DVB_DEMUX_REC_EVENT_OPCR                  = (1 <<  6), /* this packet contains an opcr */
  DVB_DEMUX_REC_EVENT_TRANSPORT_PRIVATE_DATA = (1 <<  7), /* this packet contains private data in the adaptation field*
  DVB_DEMUX_REC_EVENT_AF_EXTENSION          = (1 <<  8), /* an adaptation field extension exists within this TS packet
  DVB_DEMUX_REC_EVENT_SEQ_HEADER            = (1 <<  9), /* this packet contains the sequence header code 0xb3 */
  DVB_DEMUX_REC_EVENT_GROUP_START           = (1 << 10), /* this packet contains the group start code 0xb8 */
  DVB_DEMUX_REC_EVENT_I_FRAME               = (1 << 11), /* this packet contains the beginning of an i-frame */
  DVB_DEMUX_REC_EVENT_P_FRAME               = (1 << 12), /* this packet contains the beginning of an p-frame */
  DVB_DEMUX_REC_EVENT_B_FRAME               = (1 << 13), /* this packet contains the beginning of an n-frame */
  DVB_DEMUX_REC_EVENT_ALL                   = 0x3fff,    /* all of the events above */
};
```

describes the desired recording events which should be written to the event log.

```
/*! is used to specify one recording pid and the desired events it should trigger in the event log.
 If \c DVB_DEMUX_REC_EVENT_ALL is specified for \em flags, the driver will generate all flags
 supported
 */
struct dvb_rec_pid {
  uint16_t                pid;   /* pid to capture */
  enum dvb_demux_rec_event flags; /* desired events this item should trigger */
};
```

is used to specify one recording pid and the desired events it should trigger in the event log. If DVB_DMX_REC_EVENT_ALL is specified for *flags*, the driver will generate all flags supported (see DVB_DMX_GET_CAPS)

```
/*! is used to specify n_pids pids at once */
struct dvb_demux_recording_pids {
  uint32_t           n_pids; /* number of pids specified */
  struct dvb_rec_pid *pids;  /* array of \ref dvb_rec_pid */
};
```

is used to specify n_pids pids at once */

```
/*! sets a recording filter on the demux open using \ref dvb_demux_recording_filter

 \retval EBUSY another filter has already been set
 \retval ENODEV the demux device doesn't have any recording filters
 \retval ENOSYS the demux doesn't support the requested combination in dvb_demux_recording_type
 \retval EINVAL either buffer_size $<$ PAGE_SIZE or buffer_threshold $>$ buffer_size
 \retval E2BIG the buffer size exceeds DVB_MAX_BUFFER_SIZE
 */
#define DVB_DEMUX_SET_RECORDING_FILTER  _IOWR(DVB_IOCTL_BASE, 0x25, struct dvb_demux_recording_filter)
```

Return codes:

- EBUSY: another filter has already been set
- ENODEV: the demux device doesn't have any recording filters
- ENOSYS: the demux doesn't support the requested combination in dvb_demux_recording_type
- EINVAL: either buffer_size < PAGE_SIZE or buffer_threshold > buffer_size
- E2BIG: the buffer size exceeds DVB_MAX_BUFFER_SIZE

sets a recording filter on the demux open using `dvb_dmx_recording_filter`

6.4.4 Section filter

```
/*! describes flags for a section filter */
enum dvb_demux_section_filter_flags {
  DVB_DEMUX_SECTION_CHECK_CRC = (1 << 0), /* only deliver sections where the CRC check succeeded */
  DVB_DEMUX_SECTION_ONESHOT   = (1 << 1), /* disable the section filter after one section has been delivered*/
};
```

```
/*! describes the properties of a section filter.

 If all neg bits are zero, the filter matches when ((data & mask) == filter,
 else it matches when
   (((data & mask & ~neg) == (filter & ~neg)) &&
    ((data & mask &  neg) != (filter &  neg)))
 i.e. all non-masked data bits with neg bit 0 must match and
 at least one non-masked data bit with neg bit 1 must differ.
 */
struct dvb_demux_section_filter {
  uint16_t  pid;                            /* pid to filter */
  uint8_t   filter[DVB_DEMUX_FILTER_SIZE];  /* bytes to match */
  uint8_t   mask[DVB_DEMUX_FILTER_SIZE];    /* filter mask */
  uint8_t   neg[DVB_DEMUX_FILTER_SIZE];     /* positive or negative match */
  uint32_t  timeout;                        /* timeout in milliseconds */
  enum dvb_demux_section_filter_flags flags; /* special flags*/
  uint32_t buffer_size;                     /* in bytes, size of internal buffer */
  uint32_t buffer_threshold;                /* in bytes, notify threshold, must be <= buffer_size */
};
```

```
/*! sets a section filter
 \retval EBUSY another filter has already been set
 \retval ENODEV the demux device doesn't have any section filters
 \retval EINVAL buffer_size $<$ 4096
 \retval E2BIG the buffer size exceeds DVB_MAX_BUFFER_SIZE
 \retval ENOSYS the demux doesn't support the requested flags
 */
#define DVB_DEMUX_SET_SECTION_FILTER _IOW(DVB_IOCTL_BASE, 0x28, struct dvb_demux_section_filter)
```

Return codes:

- `EBUSY`: another filter has already been set
- `ENODEV`: the demux device doesn't have any section filters
- `EINVAL`: buffer_size $<$ 4096
- `E2BIG`: the buffer size exceeds DVB_MAX_BUFFER_SIZE
- `ENOSYS`: the demux doesn't support the requested flags

6.5 MPEG-2 PS/PES filters

MPEG-2 PS / MPEG-1 system stream / multiplexed PES filters: PS filters come in two varieties: - (MPEG) decoder feeds: data is directly DMAed to the decoder - general purpose data filters: output to memory Filtering is done primarily on the stream_id, but with DVB_DMX_PES_PRIVATE_1/2 filtering is done on the sub_stream_id (this is mainly used for DVD audio).

6.5.1 Example / Tutorial

Add examples and/or a tutorial here.

7 Common interface API

We create one "ci" device node per CI controller, i.e. each "ci" device serves all slots of that controller.

The protocol units used by this API are raw, unfragmented TPDUs. I.e. the transport layer must be implemented in userspace, but link level fragmentation is handled entirely within the driver.

poll(2) can be used in the following way:

- changes in slot status will be signaled by POLLPRI (module inserted / ready) or POLLHUP (module removed)
- available space in the send queue is signaled by POLLOUT
- available data from module is signaled by POLLIN
- other errors are signaled by POLLERR (this usually means the slot needs to be reset)

7.1 capabilites

```
/*! describes the capabilities of a controller */
enum dvb_ci_capability {
  DVB_CI_CAP_PROTOCOL,    /* supported protocols */
  DVB_CI_CAP_NUM_SLOTS,   /* number of slots */
  DVB_CI_CAP_MAX_TPDU_SIZE, /* maximum TPDU size for DVB_CI_PROTOCOL_LINK_DEFRAG */
};



/*! describes the available protocols */
enum dvb_ci_protocol {
  DVB_CI_PROTOCOL_LINK,   /* EN 50221 PCMCIA link layer */
  DVB_CI_PROTOCOL_LINK_DEFRAG /* defragmented links layer packets */
};



/*! is used to query the capabilities of a controller */
struct dvb_ci_caps {
  enum dvb_ci_capability cap; /* capabiltiy to query*/
  unsigned int           val; /* result */
};



/*! queries a specific capability of a controller */
#define DVB_CI_GET_CAPS _IOWR(DVB_IOCTL_BASE, 0xc0, struct dvb_ci_caps)
```

7.2 CI slot handling

```
/*! resets a slot */
#define DVB_CI_RESET_SLOT _IOW(DVB_IOCTL_BASE, 0xc1, int /* slot number */)


/*! describes the current ci slot status */
enum dvb_ci_cam_status {
  DVB_CI_CAM_PRESENT = (1 << 0),  /* CAM inserted */
  DVB_CI_CAM_READY   = (1 << 1),  /* CAM is initialized */
  DVB_CI_CAM_ERROR   = (1 << 2),  /* communication with CAM not possible */
};


/*! is used to get the current slot status */
struct dvb_ci_slot_status {
  int     slot;   /* slot number to query */
  enum dvb_ci_cam_status  status;   /* current status */
  unsigned int    fragment_size;  /* negotiated link level fragment size */
};


/*! queries the current slot status */
#define DVB_CI_GET_SLOT_STATUS _IOWR(DVB_IOCTL_BASE, 0xc2, struct dvb_ci_slot_status)
```

7.3 message interface

Messages with the CAM are exchanged via read() and write().

For the DVB_CI_PROTOCOL_LINK_DEFRAG protocol, each message contains one complete, unfragmented TPDU in the following format:

```
struct {
      u8 slot;      // slot number
      u8 tc_id;        // transport connection id
      u8 tpdu[];
};
```

Each write() call must write exactly one complete message. If the message is larger than the value returned by DVB_CI_CAP_MAX_TPDU_SIZE, ENOBUFS is returned. Each read() call will return at maximum one complete message, even if there are more messages pending. If the buffer is too small to read the complete message, ENOBUFS is returned.

For the DVB_CI_PROTOCOL_LINK protocol, each message contains one complete LPDU (containing one TPDU fragment) in the following format:

```
struct {
      u8 slot;      // slot number
      u8 lpdu[];
};
```

Each write() call must write exactly one complete message. If the message is larger than the fragment_size returned by DVB_CI_GET_SLOT_STATUS ENOBUFS is returned. Each read() call will return at maximum one complete message, even if there are more messages pending. If the buffer is too small to read the complete message, ENOBUFS is returned.

8 Audio API

MPEG hardware audio decoders can be found on most set-top-box chipsets. They can either retrieve the audio data from the demux or they can be fed directly from userspace.

The audio API is split in separate devices for decoding + post-processing, mixing + output control, and S/P-DIF output.

8.1 Capabilities

```
/*! describes the available audio source formats */
enum dvb_audio_source_format {
  DVB_AUDIO_FORMAT_PES   = (1 << 0), /* MPEG-2 packetized elementary stream */
  DVB_AUDIO_FORMAT_MPEG1 = (1 << 1), /* MPEG-1 system stream */
  DVB_AUDIO_FORMAT_ES    = (1 << 2), /* MPEG-2 elementary stream */
  DVB_AUDIO_FORMAT_DVD   = (1 << 3), /* MPEG-2 PES with private header processing */
  DVB_AUDIO_FORMAT_RAW   = (1 << 4), /* RAW data */
};

/*! describes the available audio encodings */
enum dvb_audio_encoding {
  DVB_AUDIO_ENC_PCM   = (1 << 0), /* PCM, fixme: pass-through to post-processing (?) */
  DVB_AUDIO_ENC_LPCM  = (1 << 1), /* LPCM */
  DVB_AUDIO_ENC_MPEG1 = (1 << 2), /* MPEG1 layer 1+2 */
  DVB_AUDIO_ENC_MPEG2 = (1 << 3), /* MPEG2 layer 1+2 */
  DVB_AUDIO_ENC_MP3   = (1 << 4), /* MPEG2 layer 3 */
  DVB_AUDIO_ENC_AC3   = (1 << 5), /* AC3 */
  DVB_AUDIO_ENC_DTS   = (1 << 6), /* DTS */
  DVB_AUDIO_ENC_AAC   = (1 << 7), /* AAC */
};

/*! describes the available audio capabilities */
enum dvb_audio_capability {
  DVB_AUDIO_CAP_SOURCE_FORMATS,   /* available source formats */
  DVB_AUDIO_CAP_ENCODINGS,        /* available encodings */
  DVB_AUDIO_CAP_NUM_SPDIF_INPUTS, /* available spdif inputs */
  DVB_AUDIO_CAP_NUM_I2S_INPUTS,   /* available i2c inputs */
};

/*! Used to query the MPEG audio decoder capabilities. */
struct dvb_audio_caps {
  enum dvb_audio_capability cap; /* cabapility to query  */
  unsigned int val;              /* output value by the driver */
};

/*! requests a capability information from the driver. Drivers are expected
 to deliver valid informations for all capabilities defined.
 \retval EINVAL the requested capability is invalid
 */
#define DVB_AUDIO_GET_CAPS _IOWR(DVB_IOCTL_BASE, 0x60, struct dvb_audio_caps)
```

Return codes:

- `EINVAL`: the requested capability is invalid

8.2 input routing and syncronisation

The decoder device needs to be opened with mode O_RDWR in order for DVB_AUDIO_SET_SOURCE to succeed. Otherwise EBADF. Each audio device can only be opened once with O_RDWR. For DVB_AUDIO_SOURCE_MEMORY the stream is passed into the audio device via write(). For DVB_AUDIO_SOURCE_DEMUX the file descriptor of the demux has to be passed in.

```
/*! describes the source type of the audio data */
enum dvb_audio_source_type {
  DVB_AUDIO_SOURCE_DEMUX,  /* pass through the corresponding demux device */
  DVB_AUDIO_SOURCE_MEMORY, /* directly into the decoder via \c write() system call */
  DVB_AUDIO_SOURCE_I2S,    /* from an external i2c interface */
  DVB_AUDIO_SOURCE_SPDIF,  /* from an external spdif interface */
};


/*! describes the audio source of the audio data */
struct dvb_audio_source {
  enum dvb_audio_source_format format; /* input source type */
  enum dvb_audio_source_type type;     /* desired source format to be delivered (DVB_AUDIO_SOURCE_MEMORY only) */
  enum dvb_audio_encoding enc;         /* audio encoding scheme */
  int input;                           /* demux fd, or source id (for I2S or SPDIF) */
};


/*!
 \li either prepares the decoder to accept audio data through the \c write() system call
 \li or configures a connection between a demux device, an i2c or an spdif interface and the decoder.
 \retval EINVAL input source type is unknown.
 \retval fixme desired source format cannot be delivered by the demux.
 */
#define DVB_AUDIO_SET_SOURCE _IOW(DVB_IOCTL_BASE, 0x61, struct dvb_audio_source)
```

Return codes:

- EINVAL: input source type is unknown.

```
/*! binds the syncronisation to a demux specified by a filedescriptor, where
 a filter of type DVB_DEMUX_FILTER_TYPE_PCR has been set or, for PS playback,
 the demux file descriptor where the audio decoder filter has been set
 */
#define DVB_AUDIO_SET_REF_STC _IOW(DVB_IOCTL_BASE, 0x62, int /* demux fd */)


/*! controls the audio syncronisation of the decoder */
#define DVB_AUDIO_SET_SYNC _IOW(DVB_IOCTL_BASE, 0x63, int /* 0 == unsynced, != 0 sync to STC */ )
```

8.3 decoder control

```
/*! start playback immediately */
#define DVB_AUDIO_START _IO(DVB_IOCTL_BASE, 0x64)


/*! stop playback immediately */
#define DVB_AUDIO_STOP _IO(DVB_IOCTL_BASE, 0x65)


/*! clear decoder buffers (necessary when stream input is not continuous,
 e.g. seeking in stream or reverse playback) */
#define DVB_AUDIO_CLEAR_BUFFER _IO(DVB_IOCTL_BASE, 0x66)
```

```
/*! describes the available audio decode channels */
enum dvb_audio_decode_channel {
  DVB_AUDIO_STEREO,
  DVB_AUDIO_MONO,
  DVB_AUDIO_DUAL_LEFT,
  DVB_AUDIO_DUAL_RIGHT,
};


/*! sets the channel output mode (not available for 5.1ch decoding) */
#define DVB_AUDIO_SET_CHANNEL _IOW(DVB_IOCTL_BASE, 0x68, enum dvb_audio_decode_channel)


/*! describes the available 5.1 channel decoding mode */
enum dvb_audio_dec_mode {
  DVB_AUDIO_DEC_MODE_STEREO,
  DVB_AUDIO_DEC_MODE_CENTRE,
  DVB_AUDIO_DEC_MODE_LCR,
  DVB_AUDIO_DEC_MODE_LRS,
  DVB_AUDIO_DEC_MODE_LCRS,
  DVB_AUDIO_DEC_MODE_LRSLSR,
  DVB_AUDIO_DEC_MODE_LCRSLSR,
};


/*! sets the channel decoding mode (not available for stereo/mono/dual) (fixme?) */
#define DVB_AUDIO_SET_DECODE_MODE _IOW(DVB_IOCTL_BASE, 0x69, enum dvb_audio_dec_mode)


/*! describes the available audio karaoke modes, fixme: what's this? */
enum dvb_audio_karaoke_mode {
  DVB_AUDIO_KARAOKE_OFF             = 0,
  DVB_AUDIO_KARAOKE_ON              = (1 << 0),
  DVB_AUDIO_KARAOKE_2_0             = 0,        /* left/right */
  DVB_AUDIO_KARAOKE_3_0             = (1 << 1), /* left, middle/melody, right */
  DVB_AUDIO_KARAOKE_NO_VOCALS       = 0,
  DVB_AUDIO_KARAOKE_VOCALS_1        = (1 << 2),
  DVB_AUDIO_KARAOKE_VOCALS_2        = (2 << 2),
  DVB_AUDIO_KARAOKE_VOCALS_BOTH     = (3 << 2),
};


/*! sets the audio karaoke mode */
#define DVB_AUDIO_SET_KARAOKE_MODE _IOW(DVB_IOCTL_BASE, 0x6a, enum dvb_audio_karaoke_mode)
```

8.4 mixer and output control

The mixer has two stages: 1) a number of inputs are mixed to a number of internal sub-groups (L, R, C, SL, SR, W, Laux, Raux, ...) Note: Not all input channels can be mixed to every sub-group, e.g. R-in cannot be mixed to L-out. This is hardware dependent. 2) the sub-groups are then fed through tone control and master volume to the outputs (TV, VCR, aux, ...) Note: Not all subgroups can be routed to every output, e.g. the aux subgroup may only be mixed to the AUX output. This is hardware dependent.

Additionally, test tones (beeps) can be generated and mixed to the outputs.

The "aux" channel is used e.g. for separate headphone outputs.

All levels are in the range 0..1000. The driver will take internal measures to prevent clipping if the hardware requires it. Bass and treble gains are in the range -1000..1000. They may not be available for every output.

I don't know any reasonable way to describe the hardware restrictions for the mixer. Simple API use cases should be portable, though.

8.5 S/P-DIF output

The S/P-DIF output can be fed from encoded stream data (the audio decode just performs synchronization), from one decoder/post-proc or from mixer output (2ch only).

```
/*! describes the possible sources for a S/P-DIF signal */
enum dvb_audio_spdif_source {
  DVB_AUDIO_SPDIF_SOURCE_PP,  /* deocder output */
  DVB_AUDIO_SPDIF_SOURCE_DEC, /* decoder output w/o post-proc */
  DVB_AUDIO_SPDIF_SOURCE_ES,  /* raw elementary stream data */
};


/*! is used to configure the S/P-DIF output */
struct dvb_audio_spdif_config {
  int source_fd;                       /* dec/post-proc or mixer file descriptor */
  enum dvb_audio_spdif_source source;  /* signal source */
  unsigned int fs;                     /* sampling frequency 32000/44100/48000 Hz */
  unsigned int word_length;            /* 16...24 bit */
};


/*! configures an S/P-DIF output */
#define DVB_AUDIO_SET_SPDIF _IOW(DVB_IOCTL_BASE, 0x80, struct dvb_audio_spdif_config)
```

8.6 post-processing

Output of the decoder can optionally be routed through a post-processor. Common post-processing algorithms include stereo downmix, Dolby Prologic or SRS decoding. However, the capabilities of different hardware vary too much to address this in a standard API.

9 Video API

The video MPEG decoder takes as input a single ES (elementary stream) or PES (packetized elementary stream), which can be written directly to the decoder with the write() system call. Multiplexed streams (MPEG-2 TS/PS/PES, MPEG-1) must be passed through the demux. Each video device can only be opened once for writing (mode O_WRONLY or O_RDWR).

Depending on hardware capabilities the input stream can be MPEG-2 or MPEG-1 video.

If the source stream for the video MPEG decoder shall come from the demux, the connection is established by passing the demux file descriptor (on which you set appropriate fiters for the video stream) through the DVB_VIDEO_SET_SOURCE ioctl.

9.1 Capabilities

```
/*! describes the different video source formats supported by the MPEG decoder. */
enum dvb_video_source_format {
  DVB_VIDEO_MPEG1_PES = (1 << 0), /* MPEG1 packetized elementary stream */
  DVB_VIDEO_MPEG1_ES  = (1 << 1), /* MPEG1 elementary stream */
  DVB_VIDEO_MPEG2_PES = (1 << 2), /* MPEG2 packetized elementary stream */
  DVB_VIDEO_MPEG2_ES  = (1 << 3), /* MPEG2 elementary stream */
};

/*! describes the capabilities of the decoder */
enum dvb_video_capability {
  DVB_VIDEO_CAP_SOURCE_FORMATS,      /* bitmask of the supported dvb_video_source_format formats */
  DVB_VIDEO_CAP_STILLPICTURE,        /* bitmask of the supported dvb_video_still_format display formats */
  DVB_VIDEO_CAP_PROFILE_LEVEL,       /* video upper decoding capability */
  DVB_VIDEO_CAP_PRESENTATION_FORMAT, /* bitmask of the supported dvb_video_presentation_format presentation_formats */
};

/*! Used to query the decoder capabilities. */
struct dvb_video_caps {
  enum dvb_video_capability cap; /* cabapility to query  */
  unsigned int              val; /* output value by the driver */
};

/*! requests a capability information from the driver. Drivers are expected
 to deliver valid informations for all capabilities defined.
 \retval EINVAL the requested capability is invalid
 */
#define DVB_VIDEO_GET_CAPS _IOWR(DVB_IOCTL_BASE, 0x40, struct dvb_video_caps)
```

Return codes:

- EINVAL: the requested capability is invalid

requests a capability information from the driver. Drivers are expected to deliver valid informations for all capabilities defined.

9.2 Input routing

```
/*! describes the input source of the video data */
enum dvb_video_source_type {
  DVB_VIDEO_SOURCE_DEMUX,        /* pass through the corresponding demux device */
  DVB_VIDEO_SOURCE_MEMORY,       /* directly into the decoder via \c write() system call */
  DVB_VIDEO_SOURCE_STILLPICTURE, /* directly into the decoder via DVB_VIDEO_STILLPICTURE ioctl*/
};


/*! Used to set the input source */
struct dvb_video_source {
  enum dvb_video_source_type   type;   /* input source type */
  /* type == DVB_VIDEO_SOURCE_MEMORY only */
  enum dvb_video_source_format format; /* desired source format to be delivered */
  /* type == DVB_VIDEO_SOURCE_DEMUX only */
  int                          fd;     /* file descriptor of the demux device */
};


/*!
 \li either configures a connection between a demux device and the decoder
 \li or prepares the MPEG video decoder to accept video data through the \c write() system call.
 \retval EINVAL input source type is unknown.
 \retval fixme desired source format cannot be delivered by the demux.
 */
#define DVB_VIDEO_SET_SOURCE _IOW(DVB_IOCTL_BASE, 0x41, struct dvb_video_source)
```

Return codes:

- EINVAL: input source type is unknown.

Either configures a connection between a demux device and the MPEG video decoder or prepares the MPEG video decoder to accept video data through the write() system call.

```
/*! is used to provide a file descriptor for a demux that is responsible
 for video synchronization.

 \li For TS playback, this has to be a demux filedescriptor
 where a filter of type \c DVB_DEMUX_FILTER_TYPE_PCR has been set.
 \li For PS playback, the demux filedescriptor where the PS is passed through has to be provided.

 For further informations about audio/video synchronization have a look at
 audio.h.

 \retval EINVAL the filedescriptor doesn't belong to a valid DVB device
 */
#define DVB_VIDEO_SET_REF_STC _IOW(DVB_IOCTL_BASE, 0x42, int /* demux fd */)
```

Return codes:

- EINVAL: the filedescriptor doesn't belong to a valid DVB device

Is used to provide a file descriptor for a demux that is responsible for video synchronization. For TS playback, this has to be a demux filedescriptor where a filter of type DVB_DMX_FILTER_TYPE_PCR has been set. For PS playback, the demux filedescriptor where the PS is passed through has to be provided. For further informations about audio/video synchronization have a look at audio.h.

9.3 Decoder control

```
/*! start video playback with specified speed:
 \li speed = 1000     : normal play
 \li 0 < speed < 1000 : slow forward
 \li speed > 1000     : fast forward
 \li speed = -1000    : reverse play
 \li -1000 < speed < 0: slow reverse
 \li speed < -1000    : fast reverse
 */
#define DVB_VIDEO_PLAY _IOW(DVB_IOCTL_BASE, 0x43, int /* speed */)
```

starts video playback with specified speed.

```
/*! stop playback immediately */
#define DVB_VIDEO_STOP _IO(DVB_IOCTL_BASE, 0x44)
```

stops playback immediately.

```
/*! freeze playback after next frame has been decoded, play state is set to frozen */
#define DVB_VIDEO_STEP _IO(DVB_IOCTL_BASE, 0x45)
```

freezes after next frame has been decoded, and send an event.

```
/*! freeze playback immediately */
#define DVB_VIDEO_FREEZE _IO(DVB_IOCTL_BASE, 0x49)
```

freeze playback immediately

```
/*! continue playback */
#define DVB_VIDEO_CONTINUE _IO(DVB_IOCTL_BASE, 0x4a)
```

continue playback

```
/*! describes special video decoding modes */
enum dvb_video_decode_mode {
  DVB_VIDEO_FRAME_I      = (1 << 0), /* I-frames only */
  DVB_VIDEO_FRAME_IP     = (1 << 1), /* I- and P-frames only*/
  DVB_VIDEO_FRAME_ANY    = (1 << 2), /* all frames */
  DVB_VIDEO_FIELD_TOP    = (1 << 3), /* only top fields */
  DVB_VIDEO_FIELD_BOTTOM = (1 << 4)  /* only bottom fields*/
};


/*! sets special video decoding modes, only valid when decoder is currently playing */
#define DVB_VIDEO_SET_DECODE_MODE _IOW(DVB_IOCTL_BASE, 0x46, enum dvb_video_decode_mode)
```

sets special video decoding modes.

```
/*! clear decoder buffers (necessary when stream input is not continuous,
 e.g. seeking in stream or reverse playback)
 \retval ENODEV the video source hasn't been set
 */
#define DVB_VIDEO_CLEAR_BUFFER _IO(DVB_IOCTL_BASE,  0x47)
```

Return codes:

- ENODEV: the video source hasn't been set

clear decoder buffers (necessary when stream input is not continuous, e.g. seeking in stream or reverse playback)

```
/*! describes the play state the decoder is in */
enum dvb_video_play_state {
  DVB_VIDEO_STOPPED, /* the decoder is idle */
  DVB_VIDEO_PLAYING, /* the decoder is playing */
  DVB_VIDEO_FROZEN,  /* the playback is currently frozen */
  DVB_VIDEO_PICTURE, /* the playback is currently showing a single I-Frame or a dripfeed */
};


/*! is used to enumerate the different status that can be queried */
enum dvb_video_status {
  DVB_VIDEO_PLAY_STATE          = (1 << 0), /* refers to enum dvb_video_play_state */
  DVB_VIDEO_DECODE_MODE         = (1 << 1), /* refers to enum dvb_video_decode_mode */
  DVB_VIDEO_PRESENTATION_FORMAT = (1 << 2), /* refers to enum dvb_video_presentation_format */
  DVB_VIDEO_ASPECT_RATIO        = (1 << 3), /* refers to enum dvb_video_aspect_ratio */
  DVB_VIDEO_SIZE                = (1 << 4), /* refers to the width and height, which are encoded like ((w << 16) | h) *
  DVB_VIDEO_ERROR_COUNT         = (1 << 5), /* refers to the count of errors since the last read (e.g. number of sequen
};


/*! is used query the status of the video decoder */
struct dvb_video_status_query {
  enum dvb_video_status status; /* mask/unmask desired status members */

  enum dvb_video_play_state          play_state;
  enum dvb_video_decode_mode         decode_mode;
  enum dvb_video_presentation_format presentation_format;
  enum dvb_video_aspect_ratio        aspect_ratio;

  unsigned int width;
  unsigned int height;
  size_t       error_count;
};


/*! queries the video deocder status items specified by 'status'. All video decoders are expected
 to support that alle items mentioned above can be queried. If used on a blocking fd, only the specified
 status bits wake up the sleep.
 \retval EINVAL fixme
 */
#define DVB_VIDEO_GET_STATUS _IOR(DVB_IOCTL_BASE, 0x4b, struct dvb_video_status_query)
```

Return codes:

- EINVAL: fixme

queries one specific video deocder status item. A video decoder is expected to support quering *all* status items mentioned above.

9.4 still picture display

```
/*! describes the format of the stillpicture to be displayed */
enum dvb_video_still_format {
  DVB_VIDEO_STILL_IFRAME = (1 << 0), /* I-frame ES (starting with sequence_header) */
  DVB_VIDEO_STILL_JPEG   = (1 << 1), /* JPEG frame */
  DVB_VIDEO_STILL_YUV    = (1 << 2), /* YUV frame */
};
```

```
/*! is used to display a stillpicture through the decoder */
struct dvb_video_still_picture {
  enum dvb_video_still_format  format; /* format of the stillpicture */
  const unsigned char         *data;   /* pointer to the stillpicture data */
  unsigned int                 size;   /* size of stillpicture data area */
};


/*! displays a stillpicture on through the video decoder */
#define DVB_VIDEO_STILLPICTURE _IOW(DVB_IOCTL_BASE, 0x4c, struct dvb_video_still_picture)
```

9.5 ES header information and decoder events

```
/*! describes the video aspect ratio */
enum dvb_video_aspect_ratio {
  DVB_VIDEO_ASPECT_RATIO_INVALID, /* unknown or invalid aspect ration */
  DVB_VIDEO_ASPECT_RATIO_4_3,     /* 4:3 aspect ratio*/
  DVB_VIDEO_ASPECT_RATIO_16_9,    /* 16:9 aspect ratio*/
  DVB_VIDEO_ASPECT_RATIO_221,     /* 2.21:1 aspect ratio */
  DVB_VIDEO_ASPECT_RATIO_1        /* source aspect ratio 1:1 (square pixels) */
};


/*! describes the video chroma format */
enum dvb_video_chroma_format {
  DVB_VIDEO_CHROMA_FORMAT_INVALID, /* invalid or unknown chroma format */
  DVB_VIDEO_CHROMA_FORMAT_420,     /* YUV420 */
  DVB_VIDEO_CHROMA_FORMAT_422,     /* YUV422 */
  DVB_VIDEO_CHROMA_FORMAT_444,     /* YUV444 */
};


/*! describes a video event type */
enum dvb_video_event_type {
  DVB_VIDEO_INVALID_EVENT           = (1 << 0), /* invalid or unknown event */
  DVB_VIDEO_FRAME_DECODED           = (1 << 1), /* first frame after starting has been decoded */
  DVB_VIDEO_PES_HEADER_CHANGED      = (1 << 2), /* the pes header has changes */
  DVB_VIDEO_SEQUENCE_HEADER_CHANGED = (1 << 3), /* the sequence header has changed (including extension, if present) */
};


/*! describes if certain header extensions are present */
enum dvb_video_header_extensions {
  DVB_VIDEO_SEQUENCE_HDR                 = (1 << 0), /* sequence header present */
  DVB_VIDEO_SEQUENCE_EXTENSION    = (1 << 1), /* sequence extension present */
  DVB_VIDEO_SEQUENCE_DISPLAY_EXTENSION  = (1 << 2), /* sequence display extension present */
  DVB_VIDEO_SEQUENCE_USER_DATA           = (1 << 3), /* user data present */
};


/*! is used to provide informations about the sequence header */
struct dvb_video_sequence_header {
  enum dvb_video_header_extensions extensions; /* bitfield, available extensions */
  /*! if DVB_VIDEO_SEQUENCE_HDR */
  unsigned int w;                              /* width */
  unsigned int h;                              /* height */
  enum dvb_video_aspect_ratio ar;              /* aspect ratio */
  unsigned int frame_rate;                     /* in frames per 1000sec */
  unsigned int bit_rate;                       /* in bit/sec */
  unsigned int vbv_buffer_size;                /* vbv buffer size */
```

```
  /*! if DVB_VIDEO_SEQUENCE_EXTENSION */
  uint8_t profile_level;             /* profile level */
  uint8_t progressive;               /* boolean, true if progressive */
  enum dvb_video_chroma_format cf;   /* chroma format */

  /*! if DVB_VIDEO_SEQUENCE_DISPLAY_EXTENSION */
  unsigned int display_vertical_size;    /* fixme */
  unsigned int display_horizontal_size;  /* fixme */
  unsigned int frame_center_vertical_offset;    /* fixme */
  unsigned int frame_center_horizontal_offset;  /* fixme */
  enum dvb_video_video_format vf;        /* video format type */

  /*! if DVB_VIDEO_SEQUENCE_USER_DATA */
  unsigned int afd;                      /* Active Format Descriptor */
};


/*! is used to provide informations about the pes header */
struct dvb_video_pes_header {
  uint8_t trick_mode_control; /* the trick mode control byte from the header */
};


/*! immediately retrieves a video event from the decoder, if an event is present.
 if O_NONBLOCK was not specified, this call will block until the next event is
 available. */
#define DVB_VIDEO_GET_EVENT _IOR(DVB_IOCTL_BASE, 0x4d, struct dvb_video_event)


/*! retrieves the last decoded sequence header from the video decoder */
#define DVB_VIDEO_GET_SEQHDR _IOR(DVB_IOCTL_BASE, 0x4e, struct dvb_video_sequence_header)
```

9.6 Presentation and auto scaling

```
/*! describes the possible video presentation formats */
enum dvb_video_presentation_format {
  DVB_VIDEO_UNSCALED        = (1 << 0),  /* unscaled or unknown presentation format */
  DVB_VIDEO_LETTER_BOX_16_9 = (1 << 1),  /* Display 16:9 letterbox on 4:3 screen */
  DVB_VIDEO_LETTER_BOX_14_9 = (1 << 2),  /* Display 14:9 letterbox on 4:3 screen */
  DVB_VIDEO_PAN_SCAN        = (1 << 3),  /* Display cut out (with pan-scan vectors) on 4:3 screen */
  DVB_VIDEO_CENTER_CUT_OUT  = (1 << 4),  /* Display center cut out on 4:3 screen */
  DVB_VIDEO_PILLARBOX       = (1 << 5),  /* Display 4:3 pillarbox on 16:9 screen */
  DVB_VIDEO_SCALE_16_9      = (1 << 6),  /* Display scaled 16:9 letterbox in 4:3 frame on a 16:9 screen */
  DVB_VIDEO_SCALE_14_9      = (1 << 7),  /* Display scaled 16:9 letterbox (shoot & protect 14:9) in a 4:3 frame on a 4
  DVB_VIDEO_SCALE_4_3       = (1 << 8),  /* Display scaled 16:9 letterbox (shoot & protect 4:3) in a 4:3 frame on a 4:3
  DVB_VIDEO_SCALE_UP        = (1 << 9),  /* Display full size scaled */
};


/*! sets the presentation format */
#define DVB_VIDEO_SET_PRESENTATION_FORMAT _IOW(DVB_IOCTL_BASE, 0x50, enum dvb_video_presentation_format)
```

10 Network API

Broadcasting IP over DVB is a common practise for Internet downstreams (”SkyDSL”).

```
/*! is used to set up a network interface */
struct dvb_net_if {
  __u16 pid;  /* pid which is carrying the data */
  __u16 if_num;   /* logical interface number */
};


/*! add network interface dvbM_N, fed by MPE packets from 'pid'
 (M: DVB adapter number, N: if_num, counting from 0);
 \retval EBUSY if if_num is already in use, or no filter for pid is available
 \retval EPERM if the caller is not root
 */
#define NET_ADD_IF    _IOWR(DVB_IOCTL_BASE, 0xa0, struct dvb_net_if)
```

Return codes:

- EBUSY: if if_num is already in use, or no filter for pid is available
- EPERM: if the caller is not root

```
/*! remove network interface
 \retval ENODEV if if_num not present
 \retval EPERM if the caller is not root
 */
#define NET_REMOVE_IF _IOW(DVB_IOCTL_BASE, 0xa1, int /* if_num */)
```

Return codes:

- ENODEV: if if_num not present
- EPERM: if the caller is not root

```
/*! retrieves informations about a network interface, if_num is input, pid is output
 \retval ENODEV if if_num not present
 */
#define NET_GET_IF    _IOWR(DVB_IOCTL_BASE, 0xa2, struct dvb_net_if)
```

Return codes:

- ENODEV: if if_num not present

11 Abbreviations

- API = application programming interface
- CI/ CA= common interface, common access
- CVS = concurrent versioning system
- DMA = direct memory access
- DSM- CC = digital storage media command and control
- DVB = digital video broadcast
- HDD = hard disk drive
- IDTV = integrated digital television
- MHP = multimedia home platform
- OSD = on- screen display
- PES = packetized elementary stream
- PS = program stream
- SPU = subtitle processing unit
- S/ P- DIF = Sony/ Philips digital interface
- STB = set top box
- TS = transport stream

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