Linux/RT-Linux CAN Driver
(LinCAN)
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Preface

LinCAN is a Linux kernel module that implements a CAN driver capable of working with multiple cards, even with different chips and IO methods. Each communication object can be accessed from multiple applications concurrently. It supports RT-Linux, 2.2, 2.4, and 2.6 with fully implemented select, poll, fasync, O_NONBLOCK, and O_SYNC semantics and multithreaded read/write capabilities. It works with the common Intel i82527, Philips 82c200, and Philips SJA1000 (in standard and PeliCAN mode) CAN controllers. It is part of a set of CAN/CANopen related components developed as part of OCERA framework.
Chapter 1. Linux/RT-Linux CAN Driver (LinCAN)

The LINCAN is an implementation of the Linux device driver supporting more CAN controller chips and many CAN interface boards. Its implementation has long history already. The OCERA version of the driver adds new features, continuous enhancements and reimplementation of structure of the driver. Most important feature is that driver supports multiple open of one communication object from more Linux and even RT-Linux applications and threads. The usage of the driver is tightly coupled to the virtual CAN API interface component which hides driver low level interface to the application programmers.

1.1. LinCAN Summary

1.1.1. Summary

Name of the component
Linux CAN Driver (LINCAN)

Author
Pavel Pisa
Arnaud Westenberg
Tomasz Motylewski

Maintainer
Pavel Pisa

LinCAN Internet resources
http://www.ocera.org OCERA project home page
http://sourceforge.net/projects/ocera OCERA SourceForge project page. The OCERA CVS relative path to LinCAN driver sources is
ocera/components/comm/can/lincan.
http://cmp.felk.cvut.cz/~pisa/can local testing directory

Reviewer
The previous driver versions were tested by more users. The actual version has been tested at CTU by more OCERA developers, by Unicontrols and by BFAD GmbH, which use pre-OCERA and current version of the driver in their products.

List of the cards tested with latest version of the driver:
• PC104 Advantech PCM3680 dual channel board on 2.4 RT-Linux enabled kernel
• PiKRON ISA card on 2.4 and 2.6 Linux kernels
• BfaD DIMM PC card on 2.4 RT-Linux enabled kernel
• KVASER pcican-q on 2.6 Linux kernel and on 2.4 RT-Linux enabled kernel
• virtual board tested on all systems as well

Supported layers

• High-level available
   Linux device interface available for soft real-time Linux only and for mixed-mode RT-Linux/Linux driver compilation

• Low-level available
RT-Linux device is registered only for mixed-mode RT-Linux/Linux driver compilation. The driver messages transmission and reception runs in hard real-time threads in such case.

Version
lincan-0.3
Status
Beta
Dependencies
The driver requires CAN interface hardware for access to real CAN bus. Driver can be used even without hardware if a virtual board is configured. This setup is useful for testing of interworking of other CAN components. Linux kernels from 2.2.x, 2.4.x and 2.6.x series are fully supported. The RT-Linux version 3.2 or OCERA RT-Linux enabled system is required for hard real-time use. The RT-Linux version requires RT-Linux malloc, which is part of OCERA RT-Linux version and can be downloaded for older RT-Linux versions. The use of VCA API library is suggested for seamless application transitions between driver kinds and versions.

Supported hardware (some not tested)

- Advantech PC-104 PCM3680 dual channel board
- PiKRON ISA card
- BfaD DIMM PC card
- KVASER PCiCan-Q, PCiCan-D, PCiCan-S
- KVASER PCcan-Q, PCcan-D, PCcan-S, PCcan-F
- MPL AG PIP5, PIP6, PIP7, PIP8
- NSI PC-104 board CAN104
- Contemporary Controls PC-104 board CAN104
- Arcom Control Systems PC-104 board AIM104CAN
- IXAT ISA board PC-I03
- SECO PC-104 board M436
- Board support template sources for yet unsupported hardware
- Virtual board

Release date
February 2004

1.2. LinCAN Driver Description

1.2.1. Introduction

The LinCAN driver is the loadable module for the Linux kernel which implements CAN driver. The driver communicates and controls one or more CAN controllers chips. Each chip/CAN interface is represented to the applications as one or more CAN message objects accessible as character devices. The application can open the character device and use read/write system calls for CAN messages transmission or reception through the connected message object. The parameters of the message object can be modified by the IOCTL system call. The closing of the character device releases resources allocated by
the application. The present version of the driver supports three most common CAN controllers:

- Intel i82527 chips
- Philips 82c200 chips
- Philips SJA1000 chips in standard and PeliCAN mode

The intelligent CAN/CANopen cards should be supported by in the near future. One of such cards is P-CAN series of cards produced by Unicontrols. The driver contains support for more than ten CAN cards basic types with different combinations of the above mentioned chips. Not all card types are held by OCERA members, but CTU has and tested more SJA1000 type cards and will test some i82527 cards in near future.

1.3. LinCAN Driver System Level API

1.3.1. Device Files and Message Structure

Each driver is a subsystem which has no direct application level API. The operating system is responsible for user space calls transformation into driver functions calls or dispatch routines invocations. The CAN driver is implemented as a character device with the standard device node names /dev/can0, /dev/cani, etc. The application program communicates with the driver through the standard system low level input/output primitives (open, close, read, write, select and ioctl). The CAN driver convention of usage of these functions is described in the next subsection.

The read and write functions need to transfer one or more CAN messages. The structure canmsg_t is defined for this purpose and is defined in include file can/can.h. The canmsg_t structure has next fields:

```c
struct canmsg_t {
    int flags;
    int cob;
    unsigned long id;
    canmsg_tstamp_t timestamp;
    unsigned short length;
    unsigned char data[CAN_MSG_LENGTH];
} PACKED;
```

flags

The flags field holds information about message type. The bit MSG_RTR marks remote transmission request messages. Writing of such message into the CAN message object handle results in transmission of the RTR message. The RTR message can be received by the read call if no buffer with corresponding ID is pre-filled in the driver. The bit MSG_EXT indicates that the message with extended (bit 29 set) ID will be send or was received. The bit MSG_OVR is intended for fast indication of the reception message queue overfill. The transmitted messages could be distributed back to the local clients after transmission to the CAN bus. Such messages are marked by MSG_LOCAL bit.

cob

The field reserved for a holding message communication object number. It could be used for serialization of received messages from more message object into one message queue in the future.

id

CAN message ID.

timestamp

The field intended for storing of the message reception time.

length

The number of the data bytes send or received in the CAN message. The number of data load bytes is from 0 to 8.
data

The byte array holding message data.

As was mentioned above, direct communication with the driver through system calls is not encouraged because this interface is partially system dependent and cannot be ported to all environments. The suggested alternative is to use OCERA provided VCA library which defines the portable and clean interface to the CAN driver implementation.

The other issue is addition of the support for new CAN interface boards and CAN controller chips. The subsection Board Support Functions describes template functions, which needs to be implemented for newly supported board. The template of board support can be found in the file src/template.c.

The other task for more brave souls is addition of the support for the unsupported chip type. The source supporting the SJA1000 chip in the PeliCAN mode can serve as an example. The full source of this chip support is stored in the file src/sja1000p.c. The subsection Chip Support Functions describes basic functions necessary for the new chip support.

1.3.2. CAN Driver File Operations

open

**Name**

open — message communication object open system call

**Synopsis**

```
int open (const char * pathname, int flags);
```

**Arguments**

- **pathname**
  
  The path to driver device node is specified there. The conventional device names for Linux CAN driver are /dev/can0, /dev/can1, etc.

- **flags**
  
  flags modifying style of open call. The standard **O_RDWR** mode should be used for CAN device. The mode **O_NOBLOCK** can be used with driver as well. This mode results in immediate return of **read** and **write**.

**Description**

Returns negative number in the case of error. Returns the file descriptor for named CAN message object in other cases.

close

**Name**

close — message communication object close system call
Chapter 1. Linux/RT-Linux CAN Driver (LinCAN)

Synopsis

```c
int close (int fd);
```

Arguments

- `fd`
  - file descriptor to opened can message communication object

Description

Returns negative number in the case of error.

---

**read**

Name

`read` — reads received CAN messages from message object

Synopsis

```c
ssize_t read (int fd, void * buf, size_t count);
```

Arguments

- `fd`
  - file descriptor to opened can message communication object
- `buf`
  - pointer to array of `canmsg_t` structures.
- `count`
  - size of message array buffer in number of bytes

Description

Returns negative value in the case of error else returns number of read bytes which is multiple of `canmsg_t` structure size.

---

**write**

Name

`write` — writes CAN messages to message object for transmission

Synopsis

```c
ssize_t write (int fd, const void * buf, size_t count);
```

Arguments

- `fd`
  - file descriptor to opened can message communication object
- `buf`
  - pointer to array of `canmsg_t` structures.
count

size of message array buffer in number of bytes. The parameter informs driver about
number of messages prepared for transmission and should be multiple of canmsg_t
structure size.

Description

Returns negative value in the case of error else returns number of bytes successfully
stored into message object transmission queue. The positive returned number is multi-
ple of canmsg_t structure size.

struct canfilt_t

Name

struct canfilt_t — structure for acceptance filter setup

Synopsis

struct canfilt_t {
    int flags;
    int queid;
    int cob;
    unsigned long id;
    unsigned long mask;
};

Members

flags

message flags

MSG_RTR .. message is Remote Transmission Request,
MSG_EXT .. message with extended ID,
MSG_OVR .. indication of queue overflow condition,
MSG_LOCAL .. message originates from this node.

there are corresponding mask bits MSG_RTR_MASK, MSG_EXT_MASK,
MSG_LOCAL_MASK.

MSG_PROCESSLOCAL enables local messages processing in the combination with
global setting

queid

CAN queue identification in the case of the multiple queues per one user (open
instance)

cob

communication object number (not used)

id

selected required value of cared ID id bits

mask

select bits significant for the comparison;

1 .. take care about corresponding ID bit,

0 .. don't care
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IOCTL CANQUE_FILTER

Name
IOCTL CANQUE_FILTER — Sets acceptance filter for CAN queue connected to client state

Synopsis

```c
int ioctl(int fd, int command = CANQUE_FILTER, struct canfilt_t * filt);
```

Arguments

- `fd`
  - file descriptor to opened can message communication object
- `command`
  - Denotes CAN queue filter command, CANQUE_FILTER
- `filt`
  - pointer to the canfilt_t structure.

Description
The CANQUE_FILTER IOCTL invocation sets acceptance mask of associated canqueue to specified parameters. Actual version of the driver changes filter of the default receiption queue. The filed queid should be initialized to zero to support compatibility with future driver versions. The call returns negative value in the case of error.

IOCTL CANQUE_FLUSH

Name
IOCTL CANQUE_FLUSH — Flushes messages from receiption CAN queue

Synopsis

```c
int ioctl(int fd, int command = CANQUE_FLUSH, int queid);
```

Arguments

- `fd`
  - file descriptor to opened can message communication object
- `command`
  - Denotes CAN queue flush command, CANQUE_FLUSH
- `queid`
  - Should be initialized to zero to support compatibility with future driver versions

Description
The call flushes all messages from the CAN queue. The call returns negative value in the case of error.
1.4. LinCAN Driver Architecture

The LinCAN provides simultaneous queued communication for more concurrent running applications.

![LinCAN architecture diagram]

Even each of communication object can be used by one or more applications, which connects to the communication object internal representation by means of CAN FIFO queues. This enables to build complex systems based even on card and chips, which provides only one communication objects (for example SJA1000).

The driver can be configured to provide virtual CAN board (software emulated message object) to test CAN components on the Linux system without hardware required to connect to the real CAN bus. The example configuration of the CAN network components connected to one real or virtual communication object of LinCAN driver is shown in figure 1-1. The communication object is used by the CAN monitor daemon and two CANopen devices implemented by OCERA CanDev component. The actual system dependent driver API is hidden to applications under VCA library. The CAN monitor daemon translates CAN messages to TCP/IP network for Java based platform independent CAN monitor and C based test client.

Each communication object is represented as character device file. The devices can be opened and closed by applications in blocking or non-blocking mode. LinCAN client application state, chip and object configurations are controlled by IOCTL system call. One or more CAN messages can be sent or received through write/read system calls. The data read from or written to the driver are formed from sequence of fixed size structures representing CAN messages.

```c
struct canmsg_t {
  int flags;
  int cob;
  unsigned long id;
  canmsg_tstamp_t timestamp;
  unsigned short length;
  unsigned char data[CAN_MSG_LENGTH];
};
```

The LinCAN driver version 0.2 has rewritten infrastructure based on message FIFOs organized into oriented edges between chip drivers (structure chip_t) message objects representations (structure msgobj_t) and open device file instances state (structure canuser_t). The complete relationship between CAN hardware representation and open instances is illustrated in the figure Figure 1-4.

The message FIFO (structure canque_fifo_t) initialization code allocates configurable number of slots capable to hold one message.
The all slots are linked to the free list after initialization. The slot can be requested by FIFO input side by function `canqueue_fifo_get_inslot`. The slot is filled by message data and is linked into FIFO queue by function `canqueue_fifo_put_inslot`. If previously requested slot is not successfully filled by data, it can be released by `canqueue_fifo_abort_inslot`. The output side of the FIFO tests presence of ready slots by function `canqueue_fifo_test_outslot`. If the slot is returned by this function, it is processed and released by function `canqueue_fifo_free_outslot`. The processing can be postponed in the case of bus error or higher priority message processing request by `canqueue_fifo_again_outslot` function. All these functions are optimized to be fast and short, which enables to synchronize them by spin-lock semaphores and guarantee atomic nature of them. The FIFO implementation is illustrated in the figure Figure 1-2.

The low level message FIFOs are wrapped by CAN edges structures (`canqueue_edge_t`), which are used for message passing between all components of the driver. The actual version of LinCAN driver uses oriented edges to connect Linux and RT-Linux clients/users with chips and communication objects. Each entity, which is able to hold edge ends, has to be equipped by `canqueue_ends_t` structure. The input ends of edges/FIFOs are held on `inlist`. The inactive/empty out ends of the edges are held on a `idle` list and active out ends are held on a `active` list corresponding to the edge priority. The `canqueue_fifo_test_outslot` function can determine by examination of active lists if there is message to accept/process. This concept makes possible to use same type of edges for outgoing and incoming directions. The concept of edges can be even used for message filtering by priority or acceptance masks. It is prepared for future targeting messages to predefined message objects according to their priority or type and for redundant and fault tolerant message distribution into more CAN buses. Message concentration, virtual nodes and other special processing can be implemented above this concept as well. The example of interconnection of one communication object with two users/open instances is illustrated in the picture Figure 1-3. Three edges/FIFOs are in the active state and one edge/FIFO is empty in the shown example.
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Figure 1-4. CAN hardware model in the LinCAN driver

The figure Figure 1-4 is example of object inside LinCAN driver representing system with two boards, three chips and more communication objects. Some of these objects are used by one or more applications. The object open instances are represented as `canuser_t` structures.

1.5. Driver History and Implementation Issues

The development of the CAN drivers for Linux has long history. We have been faced before two basic alternatives, start new project from scratch or use some other project as basis of our development. The first approach could lead faster to more simple and clean internal architecture but it would mean to introduce new driver with probably incompatible interface unusable for already existing applications. The support of many types of cards is thing which takes long time as well. More existing projects aimed to development of a Linux CAN driver has been analyzed:

Original LDDK CAN driver project

The driver project aborted on the kernel evolution and LDDK concept. The LDDK tried to prepare infrastructure for development of the kernel version independent character device drivers written in meta code. The goal was top-ranking, but it proves, that well written "C" language driver can be more portable than the LDDK complex infrastructure.

CanFestival

The big advantage of this driver is an integrated support for the RT-Linux, but driver implementation is highly coupled to one card. Some concepts of the driver are interesting but the driver has the hard-coded number of message queues.

Can-0.7.1 by Arnaud Westenberg

This driver has its roots in the LDDK project as well. The original LDDK concept has been eliminated in the driver source and necessary adaptation of the driver for the different Linux kernel versions is achieved by the controllable number of defines and conditional compilation. There is more independent contributors. The main advantages of the driver are support of many cards working in parallel, IO and memory space chip connection support and more cards of different types can be selected at module load time. There exist more users and applications compatible with the driver interface. Disadvantages of the original version of this driver
are non-optimal infrastructure, non-portable make system and lack of the select support.

The responsible OCERA developers selected the can-0.7.1 driver as a base of their development for next reasons:

• Best support for more cards in system
• Supports for many types of cards
• The internal abstraction of the peripheral access method and the chip support

The most important features added by OCERA development team are:

• Added the select system call support
• The support for our memory mapped ISA card added, which proved simplicity of addition of the support for new type of CAN cards
• Added devfs support
• Revised and bug-fixed the IRQ support in the first phase
• Added support for 2.6.x kernels
• Rebuilt the make system to compile options fully follow the running kernel options, cross-compilation still possible when the kernel location and compiler is specified. The driver checked with more 2.2.x, 2.4.x and 2.6.x kernels and hardware configurations.
• Cleaned-up synchronization required to support 2.6.x SMP kernels and enhanced 2.4.x kernels performance
• The deeper rebuilt of the driver infrastructure to enable porting to more systems (most important RT-Linux). The naive FIFO implementation has been replaced by robust CAN queues, edges and ends framework. The big advantage of continuous development is ability to keep compatibility with many cards and applications
• The infrastructure rewrite enabled to support multiple opening of the single minor device
• Support for individual queues message acceptance filters added
• The driver setup functions modified to enable PCI and USB hardware hot-swapping and PnP recognition in the future
• Added support for KVASER PCI cards family
• Added support for virtual can board for more CAN/CANopen components interworking testing on single computer without real CAN hardware.
• The conditional compilation mode for Linux/RT-Linux support has been added. The driver manipulates with chips and boards from RT-Linux hard real-time worker threads in that compilation mode. The POSIX device file interface is provided for RT-Linux threads in parallel to the standard Linux device interface.
• Work on support for first of intelligent CAN/CANopen cards has been started

The possible future enhancements

• Cleanup and enhance RTR processing. Add some support for emulated RTR processing for SJA1000 chips
• Enhance clients API to gain full advantages of possibility to connect more CAN queues with different priorities to the one user state structure
• Add support for more CAN cards and chips (82C900 comes to mind)
• Add support for XILINX FPGA based board in development at CTU. There already exists VHDL source for the chip core, connect it to PC-104 bus and LinCAN driver
• Do next steps in the PCI cards support cleanup and add Linux 2.6.x sysfs support
1.6. LinCAN Driver Internals

1.6.1. Basic Driver Data Structures

**struct canhardware_t**

**Name**

*struct canhardware_t* — structure representing pointers to all CAN boards

**Synopsis**

```c
struct canhardware_t {
    int nr_boards;
    struct rtr_id * rtr_queue;
    can_spinlock_t rtr_lock;
    struct candevice_t * candevice[MAX_HW_CARDS];
};
```

**Members**

- **nr_boards**
  - number of present boards
- **rtr_queue**
  - RTR - remote transmission request queue (expect some changes there)
- **rtr_lock**
  - locking for RTR queue
- **candevice[MAX_HW_CARDS]**
  - array of pointers to CAN devices/boards

**struct candevice_t**

**Name**

*struct candevice_t* — CAN device/board structure

**Synopsis**

```c
struct candevice_t {
    char * hwname;
    int candev_idx;
    unsigned long io_addr;
    unsigned long res_addr;
    unsigned long dev_base_addr;
    unsigned int flags;
    int nr_all_chips;
    int nr_82527_chips;
    int nr_sja1000_chips;
    struct canchip_t * chip[MAX_HW_CHIPS];
    struct hwspecops_t * hwspec cops;
    struct canhardware_t * hosthardware_p;
    union sysdevptr;
};
```

**Members**

- **hwname**
  - text string with board type
candev_idx

   board index in canhardware_t.candevice[]

io_addr

   IO/physical MEM address

res_addr

   optional reset register port

dev_base_addr

   CPU translated IO/virtual MEM address

flags

   board flags: PROGRAMMABLE_IRQ .. interrupt number can be programmed into board

nr_all_chips

   number of chips present on the board

nr_82527_chips

   number of Intel 8257 chips

nr_sja1000_chips

   number of Philips SJA100 chips

chip[MAX_HW_CHIPS]

   array of pointers to the chip structures

hwspecops

   pointer to board specific operations

hosthardware_p

   pointer to the root hardware structure

sysdevptr

   union reserved for pointer to bus specific device structure (case pcidev is used for PCI devices)

Description

The structure represent configuration and state of associated board. The driver infrastructure prepares this structure and calls board type specific board_register function. The board support provided register function fills right function pointers in hwspecops structure. Then driver setup calls functions init_hw_data, init_chip_data, init_chip_data, init_obj_data and program_irq. Function init_hw_data and init_chip_data have to specify number and types of connected chips or objects respectively. The use of nr_all_chips is preferred over use of fields nr_82527_chips and nr_sja1000_chips in the board non-specific functions. The io_addr and dev_base_addr is filled from module parameters to the same value. The request_io function can fix-up dev_base_addr field if virtual address is different than bus address.

struct canchip_t

Name

struct canchip_t — CAN chip state and type information

Synopsis

struct canchip_t {
  char * chip_type;
  int chip_idx;
  int chip_irq;
}
unsigned long chip_base_addr;
unsigned int flags;
long clock;
long baudrate;
void (*write_register)(unsigned data, unsigned long address);
void *chip_data;
unsigned short sja_cdr_reg;
unsigned short sja_ocr_reg;
unsigned short int_cpu_reg;
unsigned short int_clk_reg;
unsigned short int_bus_reg;
struct msgobj_t *msgobj[MAX_MSGOBJS];
struct chipspecops_t *chipspecops;
struct candevice_t *hostdevice;
int max_objects;
can_spinlock_t chip_lock;
#ifdef CAN_WITH_RTL
pthread_t worker_thread;
unsigned long pend_flags;
#endif
};

Members

chip_type
- text string describing chip type
chip_idx
- index of the chip in candevice_t.chip[] array
chip_irq
- chip interrupt number if any
chip_base_addr
- chip base address in the CPU IO or virtual memory space
flags
- chip flags: CHIP_CONFIGURED .. chip is configured, CHIP_SEGMENTED .. access to the chip is segmented (mainly for i82527 chips)
clock
- chip base clock frequency in Hz
baudrate
- selected chip baudrate in Hz
write_register
- write chip register function copy
read_register
- read chip register function copy
chip_data
- pointer for optional chip specific data extension
sja_cdr_reg
- SJA specific register - holds hardware specific options for the Clock Divider register. Options defined in the sja1000.h file: CDR_CLKOUT_MASK, CDR_CLK_OFF, CDR_RXINPEN, CDR_CBP, CDR_PELICAN
sja_ocr_reg
- SJA specific register - hold hardware specific options for the Output Control register. Options defined in the sja1000.h file: OCR_MODE_BIPHASE, OCR_MODE_TEST, OCR_MODE_NORMAL, OCR_MODE_CLOCK, OCR_TX0_LH, OCR_TX1_ZZ.
int_cpu_reg
- Intel specific register - holds hardware specific options for the CPU Interface register. Options defined in the i82527.h file: iCPU_CEN, iCPU_MUX, iCPU_SLP, iCPU_PWD, iCPU_DMC, iCPU_DSC, iCPU_RST.
int_clk_reg

Intel specific register - holds hardware specific options for the Clock Out register. Options defined in the i82527.h file: iCLK_CD0, iCLK_CD1, iCLK_CD2, iCLK_CD3, iCLK_SL0, iCLK_SL1.

int_bus_reg

Intel specific register - holds hardware specific options for the Bus Configuration register. Options defined in the i82527.h file: iBUS_DR0, iBUS_DR1, iBUS_DT1, iBUS_POL, iBUS_CBY.

msgobj[MAX_MSGOBJS]

array of pointers to individual communication objects

chipspecops

pointer to the set of chip specific object filled by init_chip_data function

hostdevice

pointer to chip hosting board

max_objects

maximal number of communication objects connected to this chip

chip_lock

reserved for synchronization of the chip supporting routines (not used in the current driver version)

worker_thread

chip worker thread ID (RT-Linux specific field)

 pend_flags

holds information about pending interrupt and tx_wake operations (RT-Linux specific field). Masks values: MSGOBJ_TX_REQUEST .. some of the message objects requires tx_wake call, MSGOBJ_IRQ_REQUEST .. chip interrupt processing required MSGOBJ_WORKER_WAKE .. marks, that worker thread should be waked for some of above reasons

Description

The fields write_register and read_register are copied from corresponding fields from hwspecops structure (chip->hostdevice->hwspecops->write_register and chip->hostdevice->hwspecops->read_register) to speedup can_write_reg and can_read_reg functions.

struct msgobj_t

Name

struct msgobj_t — structure holding communication object state

Synopsis

```
struct msgobj_t {
    unsigned long obj_base_addr;
    unsigned int minor;
    unsigned int object;
    unsigned long obj_flags;
    int ret;
    struct canque_ends_t * qends;
    struct canque_edge_t * tx_qedge;
    struct canque_slot_t * tx_slot;
    int tx_retry_cnt;
    struct timer_list tx_timeout;
    struct canmsg_t rx_msg;
    struct canchip_t * hostchip;
```

unsigned long rx_preconfig_id;
atomic_t obj_used;
struct list_head obj_users;
};

Members

obj_base_addr

minor
  associated device minor number
object
  object number in canchip_t structure +1
obj_flags
  message object specific flags. Masks values: MSGOBJ_TX_REQUEST .. the message
object requests TX activation MSGOBJ_TX_LOCK .. some IRQ routine or callback on
some CPU is running inside TX activation processing code
ret
  field holding status of the last Tx operation
qends
  pointer to message object corresponding ends structure
tx_qedge
  edge corresponding to transmitted message
tx_slot
  slot holding transmitted message, slot is taken from canque_test_outslot call
  and is freed by canque_free_outslot or rescheduled canque_again_outslot
tx_retry_cnt
  transmission attempt counter
tax_timeout
  can be used by chip driver to check for the transmission timeout
rx_msg
  temporary storage to hold received messages before calling to
canque_filter_msg2edges
hostchip
  pointer to the &canchip_t structure this object belongs to
rx_preconfig_id
  place to store RX message identifier for some chip types that reuse same object for
TX
obj_used
  counter of users (associated file structures for Linux userspace clients) of this object
obj_users
  list of user structures of type &canuser_t.

struct canuser_t

Name

struct canuser_t — structure holding CAN user/client state
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Synopsis

```c
struct canuser_t {
    unsigned long flags;
    struct list_head peers;
    struct canque_ends_t * qends;
    struct msgobj_t * msgobj;
    struct canque_edge_t * rx_edge0;
    union {} userinfo;
    int magic;
};
```

Members

- **flags**
  - used to distinguish Linux/RT-Linux type
- **peers**
  - for connection into list of object users
- **qends**
  - pointer to the ends structure corresponding for this user
- **msgobj**
  - communication object the user is connected to
- **rx_edge0**
  - default receive queue for filter IOCTL
- **userinfo**
  - stores user context specific information. The field `fileinfo.file` holds pointer to open device file state structure for the Linux user-space client applications
- **magic**
  - magic number to check consistency when pointer is retrieved from file private field

**struct hwspecops_t**

**Name**

`struct hwspecops_t — hardware/board specific operations`

**Synopsis**

```c
struct hwspecops_t {
    int (* request_io) (struct candevice_t *candev);
    int (* release_io) (struct candevice_t *candev);
    int (* reset) (struct candevice_t *candev);
    int (* init_hw_data) (struct candevice_t *candev);
    int (* init_chip_data) (struct candevice_t *candev, int chipnr);
    int (* init_obj_data) (struct canchip_t *chip, int objnr);
    int (* program_irq) (struct candevice_t *candev);
    void (* write_register) (unsigned data,unsigned long address);
    unsigned (* read_register) (unsigned long address);
};
```

**Members**

- **request_io**
  - reserve io or memory range for can board
- **release_io**
  - free reserved io memory range
- **reset**
  - hardware reset routine
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init_hw_data
called to initialize &candevice_t structure, mainly res_add, nr_all_chips,
nr_82527_chips, nr_sja1000_chips and flags fields

init_chip_data
called initialize each &canchip_t structure, mainly chip_type,
chip_base_addr, clock and chip specific registers. It is responsible to setup
&canchip_t->chipspecops functions for non-standard chip types (type other than
"i82527", "sja1000" or "sja1000p")

init_obj_data
called initialize each &msgobj_t structure, mainly obj_base_addr field.

program_irq
program interrupt generation hardware of the board if flag PROGRAMMABLE_IRQ is
present for specified device/board

write_register
low level write register routine

read_register
low level read register routine

struct chipspecops_t

Name
struct chipspecops_t — can controller chip specific operations

Synopsis

struct chipspecops_t {
  int (* chip_config) (struct canchip_t *chip);
  int (* baud_rate) (struct canchip_t *chip, int rate, int clock, int sjw, int sampl_pt, int flags);
  int (* standard_mask) (struct canchip_t *chip, unsigned short code, unsigned short mask);
  int (* extended_mask) (struct canchip_t *chip, unsigned long code, unsigned long mask);
  int (* message15_mask) (struct canchip_t *chip, unsigned long code, unsigned long mask);
  int (* clear_objects) (struct canchip_t *chip);
  int (* config_irqs) (struct canchip_t *chip, short irqs);
  int (* pre_read_config) (struct canchip_t *chip, struct msgobj_t *obj);
  int (* pre_write_config) (struct canchip_t *chip, struct msgobj_t *obj, struct canmsg_t *msg);
  int (* send_msg) (struct canchip_t *chip, struct msgobj_t *obj, struct canmsg_t *msg);
  int (* remote_request) (struct canchip_t *chip, struct msgobj_t *obj);
  int (* check_tx_stat) (struct canchip_t *chip);
  int (* wakeup_tx) (struct canchip_t *chip, struct msgobj_t *obj);
  int (* filtch_rq) (struct canchip_t *chip, struct msgobj_t *obj);
  int (* enable_configuration) (struct canchip_t *chip);
  int (* disable_configuration) (struct canchip_t *chip);
  int (* set_btregs) (struct canchip_t *chip, unsigned short btr0, unsigned short btr1);
  int (* attach_to_chip) (struct canchip_t *chip);
  int (* release_chip) (struct canchip_t *chip);
  int (* start_chip) (struct canchip_t *chip);
  int (* stop_chip) (struct canchip_t *chip);
  int (* irq_handler) (int irq, struct canchip_t *chip);
  int (* irq_accept) (int irq, struct canchip_t *chip);
};

Members

chip_config
  CAN chip configuration

baud_rate
  set communication parameters
standard_mask
setup of mask for message filtering
extended_mask
setup of extended mask for message filtering
message15_mask
set mask of i82527 message object 15
clear_objects
    clears state of all message object residing in chip
config_irqs
    tunes chip hardware interrupt delivery
pre_read_config
    prepares message object for message reception
pre_write_config
    prepares message object for message transmission
send_msg
    initiate message transmission
remote_request
    configures message object and asks for RTR message
check_tx_stat
    checks state of transmission engine
wakeup_tx
    wakeup TX processing
filtch_rq
    optional routine for propagation of outgoing edges filters to HW
enable_configuration
    enable chip configuration mode
disable_configuration
    disable chip configuration mode
set_btregs
    configures bitrate registers
attach_to_chip
    attaches to the chip, setups registers and possibly state informations
release_chip
    called before chip structure removal if CHIP_ATTACHED is set
start_chip
    starts chip message processing
stop_chip
    stops chip message processing
irq_handler
    interrupt service routine
irq_accept
    optional fast irq accept routine responsible for blocking further interrupts

1.6.2. Board Support Functions
The functions, which should be implemented for each supported board, are described in the next section. The functions are prefixed by boardname. The prefix template has been selected for next description.
template_request_io

Name
\texttt{template_request_io} — reserve io or memory range for can board

Synopsis
\begin{verbatim}
int template_request_io (struct candevice_t * candev);
\end{verbatim}

Arguments
\begin{verbatim}
candev
\end{verbatim}
pointer to candevice/board which asks for io. Field \texttt{io_addr} of \texttt{candev} is used in most cases to define start of the range

Description
The function \texttt{template_request_io} is used to reserve the io-memory. If your hardware uses a dedicated memory range as hardware control registers you will have to add the code to reserve this memory as well. \texttt{IO_RANGE} is the io-memory range that gets reserved, please adjust according your hardware. Example: \#define \texttt{IO_RANGE} 0x100 for i82527 chips or \#define \texttt{IO_RANGE} 0x20 for sja1000 chips in basic CAN mode.

Return Value
The function returns zero on success or -\texttt{ENODEV} on failure

File
\texttt{src/template.c}

template_release_io

Name
\texttt{template_release_io} — free reserved io memory range

Synopsis
\begin{verbatim}
int template_release_io (struct candevice_t * candev);
\end{verbatim}

Arguments
\begin{verbatim}
candev
\end{verbatim}
pointer to candevice/board which releases io

Description
The function \texttt{template_release_io} is used to free reserved io-memory. In case you have reserved more io memory, don't forget to free it here. \texttt{IO_RANGE} is the io-memory range that gets released, please adjust according your hardware. Example: \#define \texttt{IO_RANGE} 0x100 for i82527 chips or \#define \texttt{IO_RANGE} 0x20 for sja1000 chips in basic CAN mode.
Return Value
The function always returns zero

File
src/template.c

template_reset

Name
template_reset — hardware reset routine

Synopsis
int template_reset (struct candevice_t * candev);

Arguments
candev
    Pointer to candevice/board structure

Description
The function template_reset is used to give a hardware reset. This is rather hardware specific so I haven’t included example code. Don’t forget to check the reset status of the chip before returning.

Return Value
The function returns zero on success or -ENODEV on failure

File
src/template.c

template_init_hw_data

Name
template_init_hw_data — Initialize hardware cards

Synopsis
int template_init_hw_data (struct candevice_t * candev);

Arguments
candev
    Pointer to candevice/board structure
**Description**

The function template_init_hw_data is used to initialize the hardware structure containing information about the installed CAN-board. **RESET_ADDR** represents the i/o-address of the hardware reset register. **NR_82527** represents the number of Intel 82527 chips on the board. **NR_SJA1000** represents the number of Philips sjal000 chips on the board. The flags entry can currently only be **CANDEV_PROGRAMMABLE_IRQ** to indicate that the hardware uses programmable interrupts.

**Return Value**

The function always returns zero

**File**

src/template.c

---

**template_init_chip_data**

**Name**

template_init_chip_data — Initialize chips

**Synopsis**

```c
int template_init_chip_data (struct candevice_t * candev, int chipnr);
```

**Arguments**

- **candev**
  
  Pointer to candevice/board structure

- **chipnr**
  
  Number of the CAN chip on the hardware card

**Description**

The function template_init_chip_data is used to initialize the hardware structure containing information about the CAN chips. **CHIP_TYPE** represents the type of CAN chip. **CHIP_TYPE** can be “i82527” or “sja1000”. The **chip_base_addr** entry represents the start of the 'official' memory map of the installed chip. It's likely that this is the same as the **io_addr** argument supplied at module loading time. The **clock** entry holds the chip clock value in Hz. The entry **sja_cdr_reg** holds hardware specific options for the Clock Divider register. Options defined in the sjaj000.h file: sjaCDR_CLKOUT_MASK, sjaCDR_CLK_OFF, sjaCDR_RXINPEN, sjaCDR_CB, sjaCDR_PELICAN The entry **sja_ocr_reg** holds hardware specific options for the Output Control register. Options defined in the sjaj000.h file: sjaOCR_MODE_BIPHASE, sjaOCR_MODE_TEST, sjaOCR_MODE_NORMAL, sjaOCR_MODE_CLOCK, sjaOCR_TX0_LH, sjaOCR_TX1_ZZ. The entry **int_clk_reg** holds hardware specific options for the Clock Out register. Options defined in the i82527.h file: iCLK_CD0, iCLK_CD1, iCLK_CD2, iCLK_CD3, iCLK_SL0, iCLK_SL1. The entry **int_bus_reg** holds hardware specific options for the Bus Configuration register. Options defined in the i82527.h file: iBUS_DRO, iBUS_DRI, iBUS_DT1, iBUS_POL, iBUS_CBY. The entry **int_cpu_reg** holds hardware specific options for the cpu interface register. Options defined in the i82527.h file: iCPU_CEN, iCPU_MUX, iCPU_SLP, iCPU_PWD, iCPU_DMC, iCPU_DSC, iCPU_RST.
Return Value
The function always returns zero

File
src/template.c

template_init_obj_data

Name
template_init_obj_data — Initialize message buffers

Synopsis
int template_init_obj_data (struct canchip_t * chip, int objnr);

Arguments
chip
  Pointer to chip specific structure
objnr
  Number of the message buffer

Description
The function template_init_obj_data is used to initialize the hardware structure containing information about the different message objects on the CAN chip. In case of the sja1000 there's only one message object but on the i82527 chip there are 15. The code below is for a i82527 chip and initializes the object base addresses The entry obj_base_addr represents the first memory address of the message object. In case of the sja1000 obj_base_addr is taken the same as the chips base address. Unless the hardware uses a segmented memory map, flags can be set zero.

Return Value
The function always returns zero

File
src/template.c

template_program_irq

Name
template_program_irq — program interrupts

Synopsis
int template_program_irq (struct candevice_t * candev);
Arguments
candev
   Pointer to candevice/board structure

Description
The function template_program_irq is used for hardware that uses programmable interrupts. If your hardware doesn't use programmable interrupts you should not set the candevices_t->flags entry to CANDEV_PROGRAMMABLE_IRQ and leave this function unedited. Again this function is hardware specific so there's no example code.

Return value
The function returns zero on success or -ENODEV on failure

File
src/template.c

template_write_register

Name
template_write_register — Low level write register routine

Synopsis
void template_write_register (unsigned data, unsigned long address);

Arguments
data
   data to be written
address
   memory address to write to

Description
The function template_write_register is used to write to hardware registers on the CAN chip. You should only have to edit this function if your hardware uses some specific write process.

Return Value
The function does not return a value

File
src/template.c

template_read_register

Name
template_read_register — Low level read register routine
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Synopsis

unsigned template_read_register (unsigned long address);

Arguments

address  
memory address to read from

Description
The function template_read_register is used to read from hardware registers on the CAN chip. You should only have to edit this function if your hardware uses some specific read process.

Return Value
The function returns the value stored in address

File
src/template.c

1.6.3. Chip Support Functions
The controller chip specific functions are described in the next section. The functions should be prefixed by chip type. Because documentation of chip functions has been retrieved from the actual SJA1000 PeliCAN support, the function prefix is sja1000p.

sja1000p_enable_configuration

Name
sja1000p_enable_configuration — enable chip configuration mode

Synopsis
int sja1000p_enable_configuration (struct canchip_t * chip);

Arguments
chip  
pointer to chip state structure

sja1000p_disable_configuration

Name
sja1000p_disable_configuration — disable chip configuration mode

Synopsis
int sja1000p_disable_configuration (struct canchip_t * chip);
Arguments

chip
    pointer to chip state structure

**sja1000p_chip_config**

Name

sja1000p_chip_config — can chip configuration

Synopsis

```c
int sja1000p_chip_config (struct canchip_t * chip);
```

Arguments

chip
    pointer to chip state structure

Description

This function configures chip and prepares it for message transmission and reception. The function resets chip, resets mask for acceptance of all messages by call to sja1000p_extended_mask function and then computes and sets baudrate with use of function sja1000p_baud_rate.

Return Value

negative value reports error.

File

src/sja1000p.c

**sja1000p_extended_mask**

Name

sja1000p_extended_mask — setup of extended mask for message filtering

Synopsis

```c
int sja1000p_extended_mask (struct canchip_t * chip, unsigned long code, unsigned long mask);
```

Arguments

chip
    pointer to chip state structure
code
    can message acceptance code
mask
    can message acceptance mask
Return Value
negative value reports error.

File
src/sja1000p.c

sja1000p_baud_rate

Name
sja1000p_baud_rate — set communication parameters.

Synopsis
int sja1000p_baud_rate (struct canchip_t * chip, int rate, int clock, int sjw, int sampl_pt, int flags);

Arguments
chip
    pointer to chip state structure
rate
    baud rate in Hz
clock
    frequency of sja1000 clock in Hz (ISA osc is 14318000)
sjw
    synchronization jump width (0-3) prescaled clock cycles
sampl_pt
    sample point in % (0-100) sets (TSEG1+1)/(TSEG1+TSEG2+2) ratio
flags
    fields BTR1_SAM, OCMODE, OCPOL, OCTP, OCTN, CLK_OFF, CBP

Return Value
negative value reports error.

File
src/sja1000p.c

sja1000p_read

Name
sja1000p_read — reads and distributes one or more received messages

Synopsis
void sja1000p_read (struct canchip_t * chip, struct msgobj_t * obj);
Arguments

chip
  pointer to chip state structure

obj
  pointer to CAN message queue information

File
src/sja1000p.c

sja1000p_pre_read_config

Name
sja1000p_pre_read_config — prepares message object for message reception

Synopsis
int sja1000p_pre_read_config (struct canchip_t * chip, struct msgobj_t * obj);

Arguments

chip
  pointer to chip state structure

obj
  pointer to message object state structure

Return Value
negative value reports error. Positive value indicates immediate reception of message.

File
src/sja1000p.c

sja1000p_pre_write_config

Name
sja1000p_pre_write_config — prepares message object for message transmission

Synopsis
int sja1000p_pre_write_config (struct canchip_t * chip, struct msgobj_t * obj, struct canmsg_t * msg);

Arguments

chip
  pointer to chip state structure

obj
  pointer to message object state structure
**Description**
This function prepares selected message object for future initiation of message transmission by `sja1000p_send_msg` function. The CAN message data and message ID are transferred from `msg` slot into chip buffer in this function.

**Return Value**
negative value reports error.

**File**
src/sja1000p.c

### sja1000p_send_msg

**Name**
sja1000p_send_msg — initiate message transmission

**Synopsis**
```c
int sja1000p_send_msg (struct canchip_t * chip, struct msgobj_t * obj, struct canmsg_t * msg);
```

**Arguments**
- `chip`  
  pointer to chip state structure
- `obj`  
  pointer to message object state structure
- `msg`  
  pointer to CAN message

**Description**
This function is called after `sja1000p_pre_write_config` function, which prepares data in chip buffer.

**Return Value**
negative value reports error.

**File**
src/sja1000p.c

### sja1000p_check_tx_stat

**Name**
sja1000p_check_tx_stat — checks state of transmission engine
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Synopsis

```c
int sja1000p_check_tx_stat (struct canchip_t * chip);
```

Arguments

- `chip`  
  pointer to chip state structure

Return Value

- negative value reports error. Positive return value indicates transmission under way status. Zero value indicates finishing of all issued transmission requests.

File

- `src/sja1000p.c`

---

### sja1000p_set_btregs

**Name**

`sja1000p_set_btregs` — configures bitrate registers

**Synopsis**

```c
int sja1000p_set_btregs (struct canchip_t * chip, unsigned short btr0, unsigned short btr1);
```

**Arguments**

- `chip`  
  pointer to chip state structure
- `btr0`  
  bitrate register 0
- `btr1`  
  bitrate register 1

**Return Value**

- negative value reports error.

**File**

- `src/sja1000p.c`

---

### sja1000p_start_chip

**Name**

`sja1000p_start_chip` — starts chip message processing

**Synopsis**

```c
int sja1000p_start_chip (struct canchip_t * chip);
```
Arguments
chip
pointer to chip state structure

Return Value
negative value reports error.

File
src/sja1000p.c

sja1000p_stop_chip

Name
sja1000p_stop_chip — stops chip message processing

Synopsis
int sja1000p_stop_chip (struct canchip_t * chip);

Arguments
chip
pointer to chip state structure

Return Value
negative value reports error.

File
src/sja1000p.c

sja1000p_attach_to_chip

Name
sja1000p_attach_to_chip — attaches to the chip, setups registers and state

Synopsis
int sja1000p_attach_to_chip (struct canchip_t * chip);

Arguments
chip
pointer to chip state structure

Return Value
negative value reports error.
sja1000p_release_chip

**Name**

`sja1000p_release_chip` — called before chip structure removal if `CHIP_Attached` is set

**Synopsis**

```c
int sja1000p_release_chip (struct canchip_t * chip);
```

**Arguments**

- `chip`
  - pointer to chip state structure

**Return Value**

Negative value reports error.

**File**

`sra/sja1000p.c`

---

sja1000p_remote_request

**Name**

`sja1000p_remote_request` — configures message object and asks for RTR message

**Synopsis**

```c
int sja1000p_remote_request (struct canchip_t * chip, struct msgobj_t * obj);
```

**Arguments**

- `chip`
  - pointer to chip state structure
- `obj`
  - pointer to message object structure

**Return Value**

Negative value reports error.

**File**

`sra/sja1000p.c`
**sja1000p_standard_mask**

**Name**

sja1000p_standard_mask — setup of mask for message filtering

**Synopsis**

```c
int sja1000p_standard_mask (struct canchip_t * chip, unsigned short code, unsigned short mask);
```

**Arguments**

- `chip`  
  pointer to chip state structure
- `code`  
  can message acceptance code
- `mask`  
  can message acceptance mask

**Return Value**

negative value reports error.

**File**

src/sja1000p.c

---

**sja1000p_clear_objects**

**Name**

sja1000p_clear_objects — clears state of all message object residing in chip

**Synopsis**

```c
int sja1000p_clear_objects (struct canchip_t * chip);
```

**Arguments**

- `chip`  
  pointer to chip state structure

**Return Value**

negative value reports error.

**File**

src/sja1000p.c
sja1000p_config_irqs

Name
sja1000p_config_irqs — tunes chip hardware interrupt delivery

Synopsis
int sja1000p_config_irqs (struct canchip_t * chip, short irqs);

Arguments
chip
    pointer to chip state structure
irqs
    requested chip IRQ configuration

Return Value
negative value reports error.

File
src/sja1000p.c

sja1000p_irq_write_handler

Name
sja1000p_irq_write_handler — part of ISR code responsible for transmit events

Synopsis
void sja1000p_irq_write_handler (struct canchip_t * chip, struct msgobj_t * obj);

Arguments
chip
    pointer to chip state structure
obj
    pointer to attached queue description

Description
The main purpose of this function is to read message from attached queues and
transfer message contents into CAN controller chip. This subroutine is called by
sja1000p_irq_write_handler for transmit events.

File
src/sja1000p.c
**sja1000p_irq_handler**

**Name**
sja1000p_irq_handler — interrupt service routine

**Synopsis**

```c
int sja1000p_irq_handler (int irq, struct canchip_t * chip);
```

**Arguments**

- `irq`  
  interrupt vector number, this value is system specific
- `chip`  
  pointer to chip state structure

**Description**

Interrupt handler is activated when state of CAN controller chip changes, there is message to be read or there is more space for new messages or error occurs. The receive events results in reading of the message from CAN controller chip and distribution of message through attached message queues.

**File**

`src/sja1000p.c`

---

**sja1000p_wakeup_tx**

**Name**
sja1000p_wakeup_tx — wakeups TX processing

**Synopsis**

```c
int sja1000p_wakeup_tx (struct canchip_t * chip, struct msgobj_t * obj);
```

**Arguments**

- `chip`  
  pointer to chip state structure
- `obj`  
  pointer to message object structure

**Description**

Function is responsible for initiating message transmission. It is responsible for clearing of object TX_REQUEST flag

**Return Value**

negative value reports error.
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File
src/sja1000p.c

**sja1000p_fill_chipspecops**

**Name**
sja1000p_fill_chipspecops — fills chip specific operations

**Synopsis**

```c
int sja1000p_fill_chipspecops (struct canchip_t * chip);
```

**Arguments**

*chip*

pointer to chip representation structure

**Description**

The function fills chip specific operations for sja1000 (PeliCAN) chip.

**Return Value**

returns negative number in the case of fail

### 1.6.4. CAN Queues Common Structures and Functions

This part of the driver implements basic CAN queues infrastructure. It is written as much generic as possible and then specialization for each category of CAN queues clients is implemented in separate subsystem. The only synchronization mechanism required from target system are spin-lock synchronization and atomic bit manipulation. Locked sections are narrowed to the short operations. Even can message 8 bytes movement is excluded from the locked sections of the code.

**struct canque_slot_t**

**Name**

struct canque_slot_t — one CAN message slot in the CAN FIFO queue

**Synopsis**

```c
struct canque_slot_t {
    struct canque_slot_t * next;
    unsigned long slot_flags;
    struct canmsg_t msg;
};
```

**Members**

*next*

pointer to the next/younger slot

*slot_flags*

space for flags and optional command describing action associated with slot data
**Description**

This structure is used to store CAN messages in the CAN FIFO queue.

**struct canque_fifo_t**

**Name**

`struct canque_fifo_t` — CAN FIFO queue representation

**Synopsis**

```c
struct canque_fifo_t {
    unsigned long fifo_flags;
    unsigned long error_code;
    struct canque_slot_t * head;
    struct canque_slot_t ** tail;
    struct canque_slot_t * flist;
    struct canque_slot_t * entry;
    can_spinlock_t fifo_lock;
    int slotsnr;
};
```

**Members**

- `fifo_flags`  
  this field holds global flags describing state of the FIFO. CAN_FIFOF_ERROR is set when some error condition occurs. CAN_FIFOF_ERR2BLOCK defines, that error should lead to the FIFO block state. CAN_FIFOF_BLOCK state blocks insertion of the next messages. CAN_FIFOF_OVERRUN attempt to acquire new slot, when FIFO is full. CAN_FIFOF_FULL indicates FIFO full state. CAN_FIFOF_EMPTY indicates no allocated slot in the FIFO. CAN_FIFOF_DEAD condition indication. Used when FIFO is being destroyed.

- `error_code`  
  further description of error condition

- `head`  
  pointer to the FIFO head, oldest slot

- `tail`  
  pointer to the location, where pointer to newly inserted slot should be added

- `flist`  
  pointer to list of the free slots associated with queue

- `entry`  
  pointer to the memory allocated for the list slots.

- `fifo_lock`  
  the lock to ensure atomicity of slot manipulation operations.

- `slotsnr`  
  number of allocated slots

**Description**

This structure represents CAN FIFO queue. It is implemented as a single linked list of slots prepared for processing. The empty slots are stored in single linked list (`flist`).

msg  
space for one CAN message
canque_fifo_get_inslot

**Name**
canque_fifo_get_inslot — allocate slot for the input of one CAN message

**Synopsis**
```c
int canque_fifo_get_inslot (struct canque_fifo_t * fifo, struct canque_slot_t ** slotp, int cmd);
```

**Arguments**
- `fifo`  
  pointer to the FIFO structure
- `slotp`  
  pointer to location to store pointer to the allocated slot.
- `cmd`  
  optional command associated with allocated slot.

**Return Value**
The function returns negative value if there is no free slot in the FIFO queue.

canque_fifo_put_inslot

**Name**
canque_fifo_put_inslot — releases slot to further processing

**Synopsis**
```c
int canque_fifo_put_inslot (struct canque_fifo_t * fifo, struct canque_slot_t * slot);
```

**Arguments**
- `fifo`  
  pointer to the FIFO structure
- `slot`  
  pointer to the slot previously acquired by `canque_fifo_get_inslot`.

**Return Value**
The nonzero return value indicates, that the queue was empty before call to the function. The caller should wake-up output side of the queue.

canque_fifo_abort_inslot

**Name**
canque_fifo_abort_inslot — release and abort slot
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Synopsis
int canque_fifo_abort_inslot (struct canque_fifo_t * fifo, struct canque_slot_t * slot);

Arguments
fifo
   pointer to the FIFO structure
slot
   pointer to the slot previously acquired by canque_fifo_get_inslot.

Return Value
The nonzero value indicates, that fifo was full

canque_fifo_test_outslot

Name
canque_fifo_test_outslot — test and get ready slot from the FIFO

Synopsis
int canque_fifo_test_outslot (struct canque_fifo_t * fifo, struct canque_slot_t ** slotp);

Arguments
fifo
   pointer to the FIFO structure
slotp
   pointer to location to store pointer to the oldest slot from the FIFO.

Return Value
The negative value indicates, that queue is empty. The positive or zero value represents command stored into slot by the call to the function canque_fifo_get_inslot. The successfully acquired FIFO output slot has to be released by the call canque_fifo_free_outslot or canque_fifo_again_outslot.

canque_fifo_free_outslot

Name
canque_fifo_free_outslot — free processed FIFO slot

Synopsis
int canque_fifo_free_outslot (struct canque_fifo_t * fifo, struct canque_slot_t * slot);

Arguments
fifo
   pointer to the FIFO structure
slot

pointer to the slot previously acquired by canque_fifo_test_outslot.

Return Value

The returned value informs about FIFO state change. The mask CAN_FIFOF_FULL indicates, that the FIFO was full before the function call. The mask CAN_FIFOF_EMPTY informs, that last ready slot has been processed.

canque_fifo_again_outslot

Name
canque_fifo_again_outslot — interrupt and postpone processing of the slot

Synopsis

int canque_fifo_again_outslot (struct canque_fifo_t * fifo, struct canque_slot_t * slot);

Arguments

fifo

pointer to the FIFO structure

slot

pointer to the slot previously acquired by canque_fifo_test_outslot.

Return Value

The function cannot fail.

struct canque_edge_t

Name

struct canque_edge_t — CAN message delivery subsystem graph edge

Synopsis

struct canque_edge_t {
  struct canque_fifo_t fifo;
  unsigned long filtid;
  unsigned long filtmask;
  struct list_head inpeers;
  struct list_head outpeers;
  struct list_head activepeers;
  struct canque_ends_t * inends;
  struct canque_ends_t * outends;
  atomic_t edge_used;
  int edge_prio;
  int edge_num;
#ifdef CAN_WITH_RTL
  struct list_head pending_peers;
  unsigned long pending_inops;
  unsigned long pending_outops;
#endif
};
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Members

fifo
    place where primitive struct canque_fifo_t FIFO is located.
filtid
    the possible CAN message identifiers filter.
filtmask
    the filter mask, the comparison considers only filtid bits corresponding to set
    bits in the filtmask field.
inpeers
    the lists of all peers FIFOs connected by their input side (inends) to the same
    terminal (struct canque_ends_t).
outpeers
    the lists of all peers FIFOs connected by their output side (outends) to the same
    terminal (struct canque_ends_t).
activepeers
    the lists of peers FIFOs connected by their output side (outends) to the same
    terminal (struct canque_ends_t) with same priority and active state.
inends
    the pointer to the FIFO input side terminal (struct canque_ends_t).
outends
    the pointer to the FIFO output side terminal (struct canque_ends_t).
edge_used
    the atomic usage counter, mainly used for safe destruction of the edge.
edge_prio
    the assigned queue priority from the range 0 to CANQUEUE_PRIO_NR-1
edge_num
    edge sequential number intended for debugging purposes only
pending_peers
    edges with pending delayed events (RTL->Linux calls)
pending_inops
    bitmask of pending operations
pending_outops
    bitmask of pending operations

Description

This structure represents one direction connection from messages source (inends) to
message consumer (outends) fifo ends hub. The edge contains &struct canque_fifo_t for
message fifo implementation.

struct canque_ends_t

Name

struct canque_ends_t — CAN message delivery subsystem graph vertex (FIFO
ends)
Chapter 1. Linux/RT-Linux CAN Driver (LinCAN)

**Synopsis**

```c
struct canque_ends_t {
    unsigned long ends_flags;
    struct list_head active[CANQUEUE_PRIO_NR];
    struct list_head idle;
    struct list_head inlist;
    struct list_head outlist;
    can_spinlock_t ends_lock;
    void (* notify) (struct canque_ends_t *qends, struct canque_edge_t *qedge, int what);
    void * context;
    union {} endinfo;
    struct list_head dead_peers;
};
```

**Members**

- **ends_flags**
  - this field holds flags describing state of the ENDS structure.
- **active[CANQUEUE_PRIO_NR]**
  - the array of the lists of active edges directed to the ends structure with ready messages. The array is indexed by the edges priorities.
- **idle**
  - the list of the edges directed to the ends structure with empty FIFOs.
- **inlist**
  - the list of outgoing edges input sides.
- **outlist**
  - the list of all incoming edges output sides. Each of there edges is listed on one of **active** or **idle** lists.
- **ends_lock**
  - the lock synchronizing operations between threads accessing same ends structure.
- **notify**
  - pointer to notify procedure. The next state changes are notified.
    - CANQUEUE_NOTIFY_EMPTY (out->in call) - all slots are processed by FIFO out side.
    - CANQUEUE_NOTIFY_SPACE (out->in call) - full state negated => there is space for new message.
    - CANQUEUE_NOTIFY_PROC (in->out call) - empty state negated => out side is requested to process slots.
    - CANQUEUE_NOTIFY_NOUSR (both) - notify, that the last user has released the edge usage called with some lock to prevent edge disappear.
    - CANQUEUE_NOTIFY_DEAD (both) - edge is in progress of deletion.
    - CANQUEUE_NOTIFY_ATACH (both) - new edge has been attached to end.
    - CANQUEUE_NOTIFY_FILTCH (out->in call) - edge filter rules changed.
    - CANQUEUE_NOTIFY_ERROR (out->in call) - error in messages processing.
- **context**
  - space to store ends user specific information
- **endinfo**
  - space to store some other ends usage specific informations mainly for waking-up by the notify calls.
- **dead_peers**
  - used to chain ends wanting for postponed destruction

**Description**

Structure represents place to connect edges to for CAN communication entity. The zero, one or more incoming and outgoing edges can be connected to this structure.
canque_notify_inends

**Name**

`canque_notify_inends` — request to send notification to the input ends

**Synopsis**

```c
void canque_notify_inends (struct canque_edge_t * qedge, int what);
```

**Arguments**

- `qedge`  
  pointer to the edge structure
- `what`  
  notification type

---

canque_notify_outends

**Name**

`canque_notify_outends` — request to send notification to the output ends

**Synopsis**

```c
void canque_notify_outends (struct canque_edge_t * qedge, int what);
```

**Arguments**

- `qedge`  
  pointer to the edge structure
- `what`  
  notification type

---

canque_notify_bothends

**Name**

`canque_notify_bothends` — request to send notification to the both ends

**Synopsis**

```c
void canque_notify_bothends (struct canque_edge_t * qedge, int what);
```

**Arguments**

- `qedge`  
  pointer to the edge structure
- `what`  
  notification type
canque_activate_edge

**Name**
canque_activate_edge — mark output end of the edge as active

**Synopsis**
```c
void canque_activate_edge (struct canque_ends_t * inends, struct canque_edge_t * qedge);
```

**Arguments**
- `inends` input side of the edge
- `qedge` pointer to the edge structure

**Description**
Function call moves output side of the edge from idle onto active edges list. This function has to be called with edge reference count held, that is same as for most of other edge functions.

canque_filtid2internal

**Name**
canque_filtid2internal — converts message ID and filter flags into internal format

**Synopsis**
```c
unsigned int canque_filtid2internal (unsigned long id, int filtflags);
```

**Arguments**
- `id` CAN message 11 or 29 bit identifier
- `filtflags` CAN message flags

**Description**
This function maps message ID and MSG_RTR, MSG_EXT and MSG_LOCAL into one 32 bit number

canque_edge_incref

**Name**
canque_edge_incref — increments edge reference count
Synopsis

void canque_edge_incref (struct canque_edge_t * edge);

Arguments

edge
pointer to the edge structure

canque_edge_decref

Name
canque_edge_decref — decrements edge reference count

Synopsis

void canque_edge_decref (struct canque_edge_t * edge);

Arguments

edge
pointer to the edge structure

Description
This function has to be called without lock held for both ends of edge. If reference count
drops to 0, function canque_edge_do_dead is called.

canque_fifo_flush_slots

Name
canque_fifo_flush_slots — free all ready slots from the FIFO

Synopsis

int canque_fifo_flush_slots (struct canque_fifo_t * fifo);

Arguments

fifo
pointer to the FIFO structure

Description
The caller should be prepared to handle situations, when some slots are held by input
or output side slots processing. These slots cannot be flushed or their processing inter-
rupted.

Return Value
The nonzero value indicates, that queue has not been empty before the function call.
canque_fifo_init_slots

Name
canque_fifo_init_slots — initializes slot chain of one CAN FIFO

Synopsis
int canque_fifo_init_slots (struct canque_fifo_t * fifo);

Arguments
fifo
pointer to the FIFO structure

Return Value
The negative value indicates, that there is no memory to allocate space for the requested number of the slots.

canque_get_inslot

Name
canque_get_inslot — finds one outgoing edge and allocates slot from it

Synopsis
int canque_get_inslot (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp, int cmd);

Arguments
qends
ends structure belonging to calling communication object
qedgep
place to store pointer to found edge
slotp
place to store pointer to allocated slot
cmd
command type for slot

Description
Function looks for the first non-blocked outgoing edge in qends structure and tries to allocate slot from it.

Return Value
If there is no usable edge or there is no free slot in edge negative value is returned.
canque_get_inslot4id

Name
canque_get_inslot4id — finds best outgoing edge and slot for given ID

Synopsis
int canque_get_inslot4id (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp, int cmd, unsigned long id, int prio);

Arguments
qends
    ends structure belonging to calling communication object
qedgep
    place to store pointer to found edge
slotp
    place to store pointer to allocated slot
cmd
    command type for slot
id
    communication ID of message to send into edge
prio
    optional priority of message

Description
Function looks for the non-blocked outgoing edge accepting messages with given ID. If edge is found, slot is allocated from that edge. The edges with non-zero mask are preferred over edges open to all messages. If more edges with mask accepts given message ID, the edge with highest priority below or equal to required priority is selected.

Return Value
If there is no usable edge or there is no free slot in edge negative value is returned.

canque_put_inslot

Name
canque_put_inslot — schedules filled slot for processing

Synopsis
int canque_put_inslot (struct canque_ends_t * qends, struct canque_edge_t * qedge, struct canque_slot_t * slot);

Arguments
qends
    ends structure belonging to calling communication object
qedge
    edge slot belong to
**canque_abort_inslot**

**Name**
canque_abort_inslot — aborts preparation of the message in the slot

**Synopsis**

```c
int canque_abort_inslot (struct canque_ends_t *qends, struct canque_edge_t *qedge, struct canque_slot_t *slot);
```

**Arguments**

- `qends`:
  ends structure belonging to calling communication object
- `qedge`:
  edge slot belong to
- `slot`:
  pointer to the previously allocated slot

**Description**

Frees slot previously acquired by `canque_get_inslot` or `canque_get_inslot4id` function call. Used when message copying into slot fails.

**Return Value**

Positive value informs, that queue full state has been negated.

---

**canque_filter_msg2edges**

**Name**
canque_filter_msg2edges — sends message into all edges which accept its ID

**Synopsis**

```c
int canque_filter_msg2edges (struct canque_ends_t *qends, struct canmsg_t *msg);
```
Arguments

$qends$  
ends structure belonging to calling communication object

$msg$  
pointer to CAN message

Description

Sends message to all outgoing edges connected to the given ends, which accepts message communication ID.

Return Value

Returns number of edges message has been send to

---

canque_test_outslot

Name

canque_test_outslot — test and retrieve ready slot for given ends

Synopsis

```c
int canque_test_outslot (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp);
```

Arguments

$qends$  
ends structure belonging to calling communication object

$qedgep$  
place to store pointer to found edge

$slotp$  
place to store pointer to received slot

Description

Function takes highest priority active incoming edge and retrieves oldest ready slot from it.

Return Value

Negative value informs, that there is no ready output slot for given ends. Positive value is equal to the command slot has been allocated by the input side.

---

canque_free_outslot

Name

canque_free_outslot — frees processed output slot
Synopsis

```c
int canque_free_outslot (struct canque_ends_t *qends, struct canque_edge_t *qedge, struct canque_slot_t *slot);
```

Arguments

- `qends`: ends structure belonging to calling communication object
- `qedge`: edge slot belong to
- `slot`: pointer to the processed slot

Description

Function releases processed slot previously acquired by `canque_test_outslot` function call.

Return Value

Return value informs if input side has been notified to know about change of edge state

---

canque_again_outslot

Name

`canque_again_outslot` — reschedule output slot to process it again later

Synopsis

```c
int canque_again_outslot (struct canque_ends_t *qends, struct canque_edge_t *qedge, struct canque_slot_t *slot);
```

Arguments

- `qends`: ends structure belonging to calling communication object
- `qedge`: edge slot belong to
- `slot`: pointer to the slot for re-processing

Description

Function reschedules slot previously acquired by `canque_test_outslot` function call for second time processing.

Return Value

Function cannot fail.
canque_set_filt

**Name**
canque_set_filt — sets filter for specified edge

**Synopsis**
```c
int canque_set_filt (struct canque_edge_t * qedge, unsigned long filtid, unsigned long filtmask, int filtflags);
```

**Arguments**
- `qedge` pointer to the edge
- `filtid` ID to set for the edge
- `filtmask` mask used for ID match check
- `filtflags` required filter flags

**Return Value**
Negative value is returned if edge is in the process of delete.

canque_flush

**Name**
canque_flush — flush all ready slots in the edge

**Synopsis**
```c
int canque_flush (struct canque_edge_t * qedge);
```

**Arguments**
- `qedge` pointer to the edge

**Description**
Tries to flush all allocated slots from the edge, but there could exist some slots associated to edge which are processed by input or output side and cannot be flushed at this moment.

**Return Value**
The nonzero value indicates, that queue has not been empty before the function call.
canqueue_ends_init_gen

Name
canqueue_ends_init_gen — subsystem independent routine to initialize ends state

Synopsis
int canqueue_ends_init_gen (struct canque_ends_t * qends);

Arguments
qends
pointer to the ends structure

Return Value
Cannot fail.

canqueue_connect_edge

Name
canqueue_connect_edge — connect edge between two communication entities

Synopsis
int canqueue_connect_edge (struct canque_edge_t * qedge, struct canque_ends_t * inends,
                           struct canque_ends_t * outends);

Arguments
qedge
pointer to edge
inends
pointer to ends the input of the edge should be connected to
outends
pointer to ends the output of the edge should be connected to

Return Value
Negative value informs about failed operation.

canqueue_disconnect_edge

Name
canqueue_disconnect_edge — disconnect edge from communicating entities

Synopsis
int canqueue_disconnect_edge (struct canque_edge_t * qedge);
Arguments
qedge
(pointer to edge)

Return Value
Negative value means, that edge is used by somebody other and cannot be disconnected. Operation has to be delayed.

canqueue_block_inlist

Name
canqueue_block_inlist — block slot allocation of all outgoing edges of specified ends

Synopsis
void canqueue_block_inlist (struct canque_ends_t * qends);

Arguments
qends
(pointer to ends structure)

canqueue_block_outlist

Name
canqueue_block_outlist — block slot allocation of all incoming edges of specified ends

Synopsis
void canqueue_block_outlist (struct canque_ends_t * qends);

Arguments
qends
(pointer to ends structure)

canqueue_ends_kill_inlist

Name
canqueue_ends_kill_inlist — sends request to die to all outgoing edges

Synopsis
int canqueue_ends_kill_inlist (struct canque_ends_t * qends, int send_rest);
Arguments

\textit{qends}

pointer to ends structure

\textit{send\_rest}

select, whether already allocated slots should be processed by FIFO output side

Return Value

Non-zero value means, that not all edges could be immediately disconnected and that ends structure memory release has to be delayed

canqueue\_ends\_kill\_outlist

Name

canqueue\_ends\_kill\_outlist — sends request to die to all incoming edges

Synopsis

\texttt{int canqueue\_ends\_kill\_outlist (struct canque\_ends\_t * qends);} 

Arguments

\texttt{qends}

pointer to ends structure

Return Value

Non-zero value means, that not all edges could be immediately disconnected and that ends structure memory release has to be delayed

canqueue\_ends\_filt\_conjuction

Name

canqueue\_ends\_filt\_conjuction — computes conjunction of incoming edges filters

Synopsis

\texttt{int canqueue\_ends\_filt\_conjuction (struct canque\_ends\_t * qends, struct canfilt\_t * filt);} 

Arguments

\texttt{qends}

pointer to ends structure

\texttt{filt}

pointer the filter structure filled by computed filters conjunction

Return Value

Number of incoming edges
canqueue_ends_flush_inlist

Name
canqueue_ends_flush_inlist — flushes all messages in incoming edges

Synopsis
int canqueue_ends_flush_inlist (struct canque_ends_t * qends);

Arguments
qends
  pointer to ends structure

Return Value
Negative value informs about unsuccessful result

canqueue_ends_flush_outlist

Name
canqueue_ends_flush_outlist — flushes all messages in outgoing edges

Synopsis
int canqueue_ends_flush_outlist (struct canque_ends_t * qends);

Arguments
qends
  pointer to ends structure

Return Value
Negative value informs about unsuccessful result

1.6.5. CAN Queues Kernel Specific Functions

canqueue_notify_kern

Name
canqueue_notify_kern — notification callback handler for Linux userspace clients

Synopsis
void canqueue_notify_kern (struct canque_ends_t * qends, struct canque_edge_t * qedge, int what);
Arguments
qends
    pointer to the callback side ends structure
qedge
    edge which invoked notification
what
    notification type

Description
The notification event is handled directly by call of this function except case, when
called from RT-Linux context in mixed mode Linux/RT-Linux compilation. It is not
possible to directly call Linux kernel synchronization primitives in such case. The
notification request is postponed and signaled by pending_inops flags by call
canqueue_rtl2lin_check_and_pend function. The edge reference count is
increased until until all pending notifications are processed.

canqueue_ends_init_kern

Name
canqueue_ends_init_kern — Linux userspace clients specific ends initialization

Synopsis
int canqueue_ends_init_kern (struct canque_ends_t * qends);

Arguments
qends
    pointer to the callback side ends structure

canque_get_inslot4id_wait_kern

Name
canque_get_inslot4id_wait_kern — find or wait for best outgoing edge and slot
for given ID

Synopsis
int canque_get_inslot4id_wait_kern (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp, int cmd, unsigned long id, int prio);

Arguments
qends
    ends structure belonging to calling communication object
qedgep
    place to store pointer to found edge
**canque_get_inslot4id**

**Description**
Same as `canque_get_inslot4id`, except that it waits for free slot in case that queue is full. Function is specific for Linux userspace clients.

**Return Value**
If there is no usable edge negative value is returned.

---

**canque_get_outslot_wait_kern**

**Name**
canque_get_outslot_wait_kern — receive or wait for ready slot for given ends

**Synopsis**

```c
int canque_get_outslot_wait_kern (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp);
```

**Arguments**

- `qends`:
  ends structure belonging to calling communication object

- `qedgep`:
  place to store pointer to found edge

- `slotp`:
  place to store pointer to received slot

**Description**
The same as `canque_test_outslot`, except it waits in the case, that there is no ready slot for given ends. Function is specific for Linux userspace clients.

**Return Value**
Negative value informs, that there is no ready output slot for given ends. Positive value is equal to the command slot has been allocated by the input side.

---

**canque_sync_wait_kern**

**Name**
canque_sync_wait_kern — wait for all slots processing
Chapter 1. Linux/RT-Linux CAN Driver (LinCAN)

Synopsis

int canque_sync_wait_kern (struct canque_ends_t * qends, struct canque_edge_t * qedge);

Arguments

qends
ends structure belonging to calling communication object
qedge
pointer to edge

Description

Functions waits for ends transition into empty state.

Return Value

Positive value indicates, that edge empty state has been reached. Negative or zero value informs about interrupted wait or other problem.

canque_fifo_init_kern

Name
canque_fifo_init_kern — initialize one CAN FIFO

Synopsis

int canque_fifo_init_kern (struct canque_fifo_t * fifo, int slotsnr);

Arguments

fifo
pointer to the FIFO structure
slotsnr
number of requested slots

Return Value

The negative value indicates, that there is no memory to allocate space for the requested number of the slots.

canque_fifo_done_kern

Name
canque_fifo_done_kern — frees slots allocated for CAN FIFO

Synopsis

int canque_fifo_done_kern (struct canque_fifo_t * fifo);
Arguments
fifo
pointer to the FIFO structure

canque_new_edge_kern

Name
canque_new_edge_kern — allocate new edge structure in the Linux kernel context

Synopsis
struct canque_edge_t * canque_new_edge_kern (int slotsnr);

Arguments
slotsnr
required number of slots in the newly allocated edge structure

Return Value
Returns pointer to allocated slot structure or NULL if there is not enough memory to process operation.

canqueue_ends_dispose_kern

Name
canqueue_ends_dispose_kern — finalizing of the ends structure for Linux kernel clients

Synopsis
int canqueue_ends_dispose_kern (struct canque_ends_t * qends, int sync);

Arguments
qends
pointer to ends structure
sync
flag indicating, that user wants to wait for processing of all remaining messages

Return Value
Function should be designed such way to not fail.
1.6.6. CAN Queues RT-Linux Specific Functions

canqueue_rtl2lin_check_and_pend

Name
canqueue_rtl2lin_check_and_pend — postpones edge notification if called from RT-Linux

Synopsis
int canqueue_rtl2lin_check_and_pend (struct canque_ends_t * qends, struct canque_edge_t * qedge, int what);

Arguments
qends
    notification target ends
qedge
    edge delivering notification
what
    notification type

Return Value
if called from Linux context, returns 0 and leaves notification processing on caller responsibility. If called from RT-Linux contexts, schedules postponed event delivery and returns 1

canque_get_inslot4id_wait_rtl

Name
canque_get_inslot4id_wait_rtl — find or wait for best outgoing edge and slot for given ID

Synopsis
int canque_get_inslot4id_wait_rtl (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp, int cmd, unsigned long id, int prio);

Arguments
qends
    ends structure belonging to calling communication object
qedgep
    place to store pointer to found edge
slotp
    place to store pointer to allocated slot
cmd
    command type for slot
id
    communication ID of message to send into edge
**prio**

optional priority of message

**Description**

Same as `canque_get_inslot4id`, except, that it waits for free slot in case, that queue is full. Function is specific for Linux userspace clients.

**Return Value**

If there is no usable edge negative value is returned.

---

**canque_get_outslot_wait_rtl**

**Name**

`canque_get_outslot_wait_rtl` — receive or wait for ready slot for given ends

**Synopsis**

```c
int canque_get_outslot_wait_rtl (struct canque_ends_t * qends, struct canque_edge_t ** qedgep, struct canque_slot_t ** slotp);
```

**Arguments**

- `qends`:
  - ends structure belonging to calling communication object
- `qedgep`:
  - place to store pointer to found edge
- `slotp`:
  - place to store pointer to received slot

**Description**

The same as `canque_test_outslot`, except it waits in the case, that there is no ready slot for given ends. Function is specific for Linux userspace clients.

**Return Value**

Negative value informs, that there is no ready output slot for given ends. Positive value is equal to the command slot has been allocated by the input side.

---

**canque_sync_wait_rtl**

**Name**

`canque_sync_wait_rtl` — wait for all slots processing

**Synopsis**

```c
int canque_sync_wait_rtl (struct canque_ends_t * qends, struct canque_edge_t * qedge);
```
Arguments
qends
   ends structure belonging to calling communication object
qedge
   pointer to edge

Description
Functions waits for ends transition into empty state.

Return Value
Positive value indicates, that edge empty state has been reached. Negative or zero value informs about interrupted wait or other problem.

canque_fifo_init_rtl

Name
canque_fifo_init_rtl — initialize one CAN FIFO

Synopsis
int canque_fifo_init_rtl (struct canque_fifo_t * fifo, int slotsnr);

Arguments
fifo
   pointer to the FIFO structure
slotsnr
   number of requested slots

Return Value
The negative value indicates, that there is no memory to allocate space for the requested number of the slots.

canque_fifo_done_rtl

Name
canque_fifo_done_rtl — frees slots allocated for CAN FIFO

Synopsis
int canque_fifo_done_rtl (struct canque_fifo_t * fifo);

Arguments
fifo
   pointer to the FIFO structure
canque_new_edge_rtl

Name

canque_new_edge_rtl — allocate new edge structure in the RT-Linux context

Synopsis

struct canque_edge_t * canque_new_edge_rtl (int slotsnr);

Arguments

slotsnr
required number of slots in the newly allocated edge structure

Return Value

Returns pointer to allocated slot structure or NULL if there is not enough memory to process operation.

canqueue_notify_rtl

Name

canqueue_notify_rtl — notification callback handler for Linux userspace clients

Synopsis

void canqueue_notify_rtl (struct canque_ends_t * qends, struct canque_edge_t * qedge, int what);

Arguments

qends
pointer to the callback side ends structure
qedge
edge which invoked notification
what
notification type

canqueue_ends_init_rtl

Name

canqueue_ends_init_rtl — RT-Linux clients specific ends initialization

Synopsis

int canqueue_ends_init_rtl (struct canque_ends_t * qends);
Arguments
qends
pointer to the callback side ends structure

canqueue_ends_dispose_rtl

Name
canqueue_ends_dispose_rtl — finalizing of the ends structure for Linux kernel clients

Synopsis
int canqueue_ends_dispose_rtl (struct canque_ends_t * qends, int sync);

Arguments
qends
pointer to ends structure
sync
flag indicating, that user wants to wait for processing of all remaining messages

Return Value
Function should be designed such way to not fail.

canqueue_rtl_initialize

Name
canqueue_rtl_initialize — initialization of global RT-Linux specific features

Synopsis
void canqueue_rtl_initialize ( void);

Arguments
void
no arguments

canqueue_rtl_done

Name
canqueue_rtl_done — finalization of global RT-Linux specific features
Synopsis

```c
void canqueue_rtl_done ( void);
```

Arguments

```c
void
no arguments
```

### 1.6.7. CAN Queues CAN Chips Specific Functions

**canqueue_notify_chip**

**Name**

`canqueue_notify_chip` — notification callback handler for CAN chips ends of queues

**Synopsis**

```c
void canqueue_notify_chip ( struct canque_ends_t * qends, struct canque_edge_t * qedge, int what);
```

**Arguments**

- `qends` — pointer to the callback side ends structure
- `qedge` — edge which invoked notification
- `what` — notification type

**Description**

This function has to deal with more possible cases. It can be called from the kernel or interrupt context for Linux only compilation of driver. The function can be called from kernel context or RT-Linux thread context for mixed mode Linux/RT-Linux compilation.

**canqueue_ends_init_chip**

**Name**

`canqueue_ends_init_chip` — CAN chip specific ends initialization

**Synopsis**

```c
int canqueue_ends_init_chip ( struct canque_ends_t * qends, struct canchip_t * chip, struct msgobj_t * obj);
```

**Arguments**

- `qends` — pointer to the ends structure
chip
  pointer to the corresponding CAN chip structure

obj
  pointer to the corresponding message object structure

canqueue_ends_done_chip

Name
canqueue_ends_done_chip — finalizing of the ends structure for CAN chips

Synopsis
int canqueue_ends_done_chip (struct canque_ends_t * qends);

Arguments
qends
  pointer to ends structure

Return Value
Function should be designed such way to not fail.

1.6.8. CAN Boards and Chip Setup specific Functions
can_checked_malloc

Name
can_checked_malloc — memory allocation with registering of requested blocks

Synopsis
void * can_checked_malloc (size_t size);

Arguments
size
  size of the requested block

Description
The function is used in the driver initialization phase to catch possible memory leaks for future driver finalization or case, that driver initialization fail.

Return Value
pointer to the allocated memory or NULL in the case of fail
can_checked_free

**Name**
can_checked_free — free memory allocated by can_checked_malloc

**Synopsis**
```c
int can_checked_free (void * address_p);
```

**Arguments**
- `address_p` pointer to the memory block

---

can_del_mem_list

**Name**
can_del_mem_list — check for stale memory allocations at driver finalization

**Synopsis**
```c
int can_del_mem_list (void);
```

**Arguments**
- `void` no arguments

**Description**
Checks, if there are still some memory blocks allocated and releases memory occupied by such blocks back to the system

---

can_request_io_region

**Name**
can_request_io_region — request IO space region

**Synopsis**
```c
int can_request_io_region (unsigned long start, unsigned long n, const char * name);
```

**Arguments**
- `start` the first IO port address
- `n` number of the consecutive IO port addresses
**can_release_io_region**

**Name**

can_release_io_region — release IO space region

**Synopsis**

```c
void can_release_io_region (unsigned long start, unsigned long n);
```

**Arguments**

- `start`
  - the first IO port address
- `n`
  - number of the consecutive IO port addresses

**can_request_mem_region**

**Name**

can_request_mem_region — request memory space region

**Synopsis**

```c
int can_request_mem_region (unsigned long start, unsigned long n, const char * name);
```

**Arguments**

- `start`
  - the first memory port physical address
- `n`
  - number of the consecutive memory port addresses
- `name`
  - name/label for the requested region

**Description**
The function hides system specific implementation of the feature.
Return Value
returns positive value (1) in the case, that region could be reserved for the driver. Returns zero (0) if there is collision with other driver or region cannot be taken for some other reason.

can_release_mem_region

Name
can_release_mem_region — release memory space region

Synopsis
void can_release_mem_region (unsigned long start, unsigned long n);

Arguments
start
the first memory port physical address
n
number of the consecutive memory port addresses

can_base_addr_fixup

Name
can_base_addr_fixup — relocates board physical memory addresses to the CPU accessible ones

Synopsis
int can_base_addr_fixup (struct candevice_t * candev, unsigned long new_base);

Arguments
candev
pointer to the previously filled device/board, chips and message objects structures
new_base
candev new base address

Description
This function adapts base addresses of all structures of one board to the new board base address. It is required for translation between physical and virtual address mappings. This function is prepared to simplify board specific xxx_request_io function for memory mapped devices.
can_check_dev_taken

**Name**

can_check_dev_taken — checks if bus device description is already taken by driver

**Synopsis**

```c
int can_check_dev_taken (void * anydev);
```

**Arguments**

- `anydev`  
  pointer to bus specific Linux device description

**Returns**

Returns 1 if device is already used by LinCAN driver, 0 otherwise.

register_obj_struct

**Name**

register_obj_struct — registers message object into global array

**Synopsis**

```c
int register_obj_struct (struct msgobj_t * obj, int minorbase);
```

**Arguments**

- `obj`  
  the initialized message object being registered
- `minorbase`  
  wanted minor number, if (-1) automatically selected

**Return Value**

returns negative number in the case of fail

register_chip_struct

**Name**

register_chip_struct — registers chip into global array

**Synopsis**

```c
int register_chip_struct (struct canchip_t * chip, int minorbase);
```
Arguments

chip
  the initialized chip structure being registered
minorbase
  wanted minor number base, if (-1) automatically selected

Return Value
returns negative number in the case of fail

init_hw_struct

Name
init_hw_struct — initializes driver hardware description structures

Synopsis
int init_hw_struct ( void);

Arguments
void
  no arguments

Description
The function init_hw_struct is used to initialize the hardware structure.

Return Value
returns negative number in the case of fail

init_device_struct

Name
init_device_struct — initializes single CAN device/board

Synopsis
int init_device_struct (int card, int * chan_param_idx_p, int * irq_param_idx_p);

Arguments
card
  index into hardware_p HW description
chan_param_idx_p
  pointer to the index into arrays of the CAN channel parameters
irq_param_idx_p
  pointer to the index into arrays of the per CAN channel IRQ parameters
Description
The function builds representation of the one board from parameters provided

in the module parameters arrays
hw[card] .. hardware type, io[card] .. base IO address, baudrate[chan_param_idx] .. per channel baudrate, minor[chan_param_idx] .. optional specification of requested channel minor base, irq[irq_param_idx] .. one or more board/chips IRQ parameters. The indexes are advanced after consumed parameters if the registration is successful.

The hardware specific operations of the device/board are initialized by call to init_hwspecops function. Then board data are initialized by board specific init_hw_data function. Then chips and objects representation is build by init_chip_struct function. If all above steps are successful, chips and message objects are registered into global arrays.

Return Value
returns negative number in the case of fail

init_chip_struct

Name
init_chip_struct — initializes one CAN chip structure

Synopsis
int init_chip_struct (struct candevice_t * candev, int chipnr, int irq, long baudrate);

Arguments
candev
    pointer to the corresponding CAN device/board
chipnr
    index of the chip in the corresponding device/board structure
irq
    chip IRQ number or (-1) if not appropriate
baudrate
    baudrate in the units of 1Bd

Description
Chip structure is allocated and chip specific operations are filled by call to board specific init_chip_data which calls chip specific fill_chipspecops. The message objects are generated by calls to init_obj_struct function.

Return Value
returns negative number in the case of fail
init_obj_struct

**Name**
init_obj_struct — initializes one CAN message object structure

**Synopsis**
```c
int init_obj_struct (struct candevice_t * candev, struct canchip_t * hostchip, int objnr);
```

**Arguments**
candev
  pointer to the corresponding CAN device/board

hostchip
  pointer to the chip containing this object

objnr
  index of the builted object in the chip structure

**Description**
The function initializes message object structure and allocates and initializes CAN queue chip ends structure.

**Return Value**
returns negative number in the case of fail

init_hwspecops

**Name**
init_hwspecops — finds and initializes board/device specific operations

**Synopsis**
```c
int init_hwspecops (struct candevice_t * candev, int * irqnum_p);
```

**Arguments**
candev
  pointer to the corresponding CAN device/board

irqnum_p
  optional pointer to the number of interrupts required by board

**Description**
The function searches board hwname in the list of supported boards types. The board type specific board_register function is used to initialize hwspecops operations.

**Return Value**
returns negative number in the case of fail
can_default_irq_dispatch

Name
can_default_irq_dispatch — the first level interrupt dispatch handler

Synopsis
can_irqreturn_t can_default_irq_dispatch (int irq, void * dev_id, struct pt_regs * regs);

Arguments
irq
interrupt vector number, this value is system specific
dev_id
driver private pointer registered at time of request_irq call. The CAN driver uses this pointer to store relationship of interrupt to chip state structure - struct canchip_t
regs
system dependent value pointing to registers stored in exception frame

File
src/setup.c

can_chip_setup_irq

Name
can_chip_setup_irq — attaches chip to the system interrupt processing

Synopsis
int can_chip_setup_irq (struct canchip_t * chip);

Arguments
chip
pointer to CAN chip structure

Return Value
returns negative number in the case of fail

can_chip_free_irq

Name
can_chip_free_irq — unregisters chip interrupt handler from the system
Synopsis

```c
void can_chip_free_irq (struct canchip_t * chip);
```

Arguments

- `chip` pointer to CAN chip structure

1.6.9. CAN Boards and Chip Finalization Functions

**msgobj_done**

**Name**

`msgobj_done` — destroys one CAN message object

**Synopsis**

```c
void msgobj_done (struct msgobj_t * obj);
```

**Arguments**

- `obj` pointer to CAN message object structure

**canchip_done**

**Name**

`canchip_done` — destroys one CAN chip representation

**Synopsis**

```c
void canchip_done (struct canchip_t * chip);
```

**Arguments**

- `chip` pointer to CAN chip structure

**candevice_done**

**Name**

`candevice_done` — destroys representation of one CAN device/board
Synopsis

```c
void candevice_done (struct candevice_t * candev);
```

Arguments

candeve

pointer to CAN device/board structure

---

**canhardware_done**

**Name**

canhardware_done — destroys representation of all CAN devices/boards

**Synopsis**

```c
void canhardware_done (struct canhardware_t * canhw);
```

Arguments

canhw

pointer to the root of all CAN hardware representation

---

### 1.7. LinCAN Usage Information

#### 1.7.1. Installation Prerequisites

The next basic conditions are necessary for the LinCAN driver usage:

- some of supported types of CAN interface boards (high or low speed). Not required for virtual board setup.
- cables and at least one device compatible with the board or the second computer with another CAN interface board. Not required for virtual board setup. Even more clients can communicate each with another if process local is enabled for real chip driver.
- working Linux system with any recent 2.6.x, 2.4.x or 2.2.x kernel (successfully tested on 2.4.18, 2.4.22, 2.2.19, 2.2.20, 2.2.22, 2.6.0 kernels) or working setup for kernel cross-compilation.
- installed native and or target specific development tools (GCC and binutils) and pre-configured kernel sources corresponding to the running kernel or intended target for cross-compilation.

Every non-archaic Linux distribution should provide good starting point for the LinCAN driver installation.

If mixed mode compilation for Linux/RT-Linux is required, additional conditions has to be fulfilled:

- RT-Linux version 3.2 or higher is required and RT-Linux enabled Linux kernel sources and configuration has to be prepared. The recommended is use of OCERA Linux/RT-Linux release (http://www.ocera.org).
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- RT-Linux real-time malloc support. It is already included in the OCERA release. It can be downloaded from OCERA website for older RT-Linux releases as well (http://www.ocera.org/download/components/index.html).

The RT-Linux specific Makefiles infrastructure is not distributed with the current standard LinCAN distribution yet. Please, download full OCERA-CAN package or retrieve sources from CVS by next command:

```
cvs -d:pserver:anonymous@cvs.ocera.sourceforge.net:/cvsroot/ocera login
cvs -z3 -d:pserver:anonymous@cvs.ocera.sourceforge.net:/cvsroot/ocera co ocera/components/comm/can
```

1.7.2. Quick Installation Instructions

Change current directory into the LinCAN driver source root directory

```
cd lincan-dir
```

invoke make utility. Just type `make` at the command line and driver should compile without errors

```
make
```

If there is problem with compilation, look at first lines produced by `make` command or store make output in file. More about possible problems and more complex compilation examples is in the next subsection.

Install built LinCAN driver object file (can.o) into Linux kernel loadable module directory (`/lib/modules/2.x.y/kernel/drivers/char`). This and next commands needs root privileges to proceed successfully.

```
make install
```

If device filesystem (devfs) is not used on the computer, device nodes have to be created manually.

```
mknod -m666 /dev/can0 c 91 0
mknod -m666 /dev/can1 c 91 1
...
mknod -m666 /dev/can7 c 97 7
```

The parameters, IO address and interrupt line of inserted CAN interface card need to be determined and configured. The manual driver load can be invoked from the command line with parameters similar to example below

```
insmod can.o hw=pip5 irq=4 io=0x8000
```

This commands loads module with selected one card support for PIP5 board type with IO port base address `0x8000` and interrupt line `4`. The full description of module parameters is in the next subsection. If module starts correctly utilities from `utils` subdirectory can be used to test CAN message interchange with device or another computer. The parameters should be written into file `/etc/modules.conf` for subsequent module startup by `modprobe` command.

Line added to file `/etc/modules.conf` follows

```
options can hw=pip5 irq=4 io=0x8000
```

The module dependencies should be updated by command

```
depmod -a
```

The driver can be now stopped and started by simple `modprobe` command

```
modprobe -r can modprobe can
```
1.7.3. Installation instructions

The LinCAN make solutions tries to fully automate native kernel out of tree module compilation. Make system recurses through kernel Makefile to achieve selection of right preprocessor, compiler and linker directives. The description of make targets after make invocation in driver top directory follows

```
lincan-drv/Makefile (all)
   LinCAN driver top makefile
lincan-drv/src/Makefile (default or all => make_this_module)
   Needs to resolve target system kernel sources location. This can be selected manually by uncommenting the Makefile definition
   KERNEL_LOCATION=/usr/src/linux-2.2.22. The default behavior is to find the running kernel version and look for path to sources of found kernel version in /lib/modules/2.x.y/build directory. If no such directory exists, older version of kernel is assumed and makefile tries the /usr/src/linux directory.
lib/modules/2.x.y/build/Makefile SUBDIRS=../lincan-drv/src (modules)
   The kernel supplied Makefile is responsible for defining of right defines for preprocessor, compiler and linker. If the Linux kernel is cross-compiled, Linux kernel sources root Makefile needs be edited before Linux kernel compilation. The variable CROSS_COMPILE should contain development tool-chain prefix, for example arm-linux-. The Linux kernel make process recurses back into LinCAN driver src/Makefile.
lincan-drv/src/Makefile (modules)
   This pass starts real LinCAN driver build actions.
If there is problem with automatic build process, the next commands can help to diagnose the problem.
   make clean make >make.out 2>&1
   The first lines of file make.out indicates auto-detected values and can help with resolving of possible problems.
```

```
make -C src default ;
make -C utils default ;
make[1]: /scripts/pathdown.sh: Command not found
make[1]: Entering directory '/usr/src/can-0.7.1-pi3.4/src'
   echo >.supported_cards.h echo '#define ENABLE_CARD_pip 1 >>.supported_cards.h ; ...
Linux kernel version 2.4.19
   echo Linux kernel sources /lib/modules/2.4.19/build
   echo Module target can.o
   Module target can.o
   echo Module objects proc.o pip.o pccan.o smartcan.o nsi.o ...
make[2]: Entering directory '/usr/src/linux-2.4.19'
The driver size can be decreased by restricting of number of supported types of boards. This can be done by editing of definition for SUPPORTED_CARDS variable.
There is complete description of driver supported parameters.
```

```
   insmod can.o hw='your hardware' irq='irq number' io='io address' <more options>
```

The more values can be specified for hw, irq and io parameters if more cards is used. Values are separated by commas in such case. The hw argument can be one of:

- pip5, for the PIP5 computer by MPL AG
- pip6, for the PIP6 computer by MPL AG
- pip7, for the PIP7 computer by MPL AG
- pip8, for the PIP8 computer by MPL AG
- pccan-q, for the PCcan-Q ISA card by KVASER
- pccan-f, for the PCcan-F ISA card by KVASER
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- pccan-s, for the PCcan-S ISA card by KVASER
- pccan-d, for the PCcan-D ISA card by KVASER
- pcican-q, for the PCican-Q PCI card by KVASER (4x SJA1000)
- pcican-d, for the PCican-D PCI card by KVASER (2x SJA1000)
- pcican-s, for the PCican-S PCI card by KVASER (1x SJA1000)
- nsican, for the CAN104 PC/104 card by NSI
- cc104, for the CAN104 PC/104 card by Contemporary Controls
- aim104, for the AIM104CAN PC/104 card by Arcom Control Systems
- pc-i03, for the PC-I03 ISA card by IXXAT
- pcm3680, for the PCM-3680 PC/104 card by Advantech
- m437, for the M436 PC/104 card by SECO
- bfadcan for sja1000 CAN embedded card made by BFAD GmbH
- pikronisa for ISA memory mapped sja1000 CAN card made by PiKRON Ltd.
- template, for yet unsupported hardware (you need to edit src/template.c)
- virtual, virtual/dummy board support for testing of driver and software devices and applications

The lists of values for board hardware type (hw) and board base IO address (io) parameters have to contain same number of values. If the value of io has no meaning for specified hardware type (virtual or PCI board), it has to be substituted by 0.

The number of required irq values per board is variable. The virtual and PCI board demands no value, most of the other boards requires one irq value per each chip/channel.

The <more options> can be one or more of:

- major=<nr>, major specifies the major number of the driver. Default value is 91
- minor=<nr>, you can specify which base minor number the driver should use for each can channel/chip. Consecutive numbers are taken in the case, that chip supports more communication objects. The values for channels are separated by comas
- extended=[1|0], enables automatic switching to extended format if ID>2047, selects extended frames reception for i82527
- pelican=[1|0], unused parameter, PeliCAN used by default for sja1000p chips now
- baudrate=<nr>, baudrate for each channel in step of 1kBd
- clock_freq=<nr>, the frequency of the CAN quartz for BfaD board
- stdmask=<nr>, default standard mask for some (i82527) chips
- extmask=<nr>, default extended mask for some (i82527) chips
- mo15mask=<nr>, sets the mask for message object 15 (i82527 only)
- processlocal=<nr>, select post-processing/loop-back of transmitted messages
  0 .. disabled
  1 .. can be enabled by application by FIFO filter setup
  2 .. enabled by default

- can_rtl_priority=<nr>, select priority of chip worker thread for driver compiled with RT-Linux support

Actual list of supported CAN module parameters and short description can be reached by invocation of the command

```
modinfo can
```
1.7.4. Simple Utilities

The simple test utilities can be found in the \texttt{utils} subdirectory of the LinCAN driver source subtree. These utilities can be used as base for user programs directly communicating with the LinCAN driver. We do not suggest to build applications directly dependent on the driver operating system specific interface. We suggest to use the VCA API library for communication with the driver which brings higher level of system interface abstraction and ensures compatibility with the future versions of LinCAN driver and RT-Linux driver clone versions. The actual low level RT-Linux API to LinCAN driver closely matches \texttt{open/c}lose, \texttt{read/write} and \texttt{ioctl} interface. Only \texttt{select} cannot be provided directly by RT-Linux API.

The basic utilities provided with LinCAN driver are:

- \texttt{rxtx} — the simple utility to receive or send message which guides user through operation, the message type, the message ID and the message contents by simple prompts
- \texttt{send} — even more simplistic message sending program
- \texttt{readburst} — the utility for continuous messages reception and printing of the message contents. This utility can be used as an example of the \texttt{select} system call usage.
- \texttt{sendburst} — the periodic message generator. Each message is filled by the constant pattern and the message sequence number. This utility can be used for throughput and message drops tests.
- \texttt{can-proxy} — the simple TCP/IP to CAN proxy. The proxy receives simple commands from IP datagrams and processes command sending and state manipulations. Received messages are packed into IP datagrams and send back to the client.

\textbf{readburst}

\textbf{Name}

\texttt{readburst} — the utility for continuous messages reception and printing of the message contents

\textbf{Synopsis}

\texttt{readburst} \([-d \ candev] \ [-m \ mask] \ [-i \ id] \ [-f \ flags] \ [-w \ sec] \ [-p \ prefix] [-V] [-h]

\textbf{Description}

The utility \texttt{readburst} can be used to monitor or log CAN messages received by one CAN message communication object. Even outgoing transmitted messages can be logged if \texttt{process local} is globally or explicitly enabled.

\textbf{OPTIONS}

- \texttt{-d --device} — This option selects \texttt{readburst} target CAN device. If the option is not specified, default device name \texttt{/dev/can0} is used.
- \texttt{-m --mask} — This option enables to change default mask accepting all messages to the specified CAN message id mask. The hexadecimal value has to be prefixed by prefix \texttt{0x}. Numeric value without any prefix is considered as decimal one.
-i --id
This option specifies CAN message identifier in the acceptance mask. The accepted CAN messages are then printed by `readburst` command. Only bits corresponding to the non-zero bits of acceptance mask are compared. Hexadecimal value has to be prefixed by any prefix `0x`. Numeric value without prefix is considered as decimal one.

-f --flags
Specification of modifiers flags of reception CAN queur. Hexadecimal value has to be prefixed by prefix `0x`. Numeric value without any prefix is considered as decimal one.

<table>
<thead>
<tr>
<th>Bit name</th>
<th>Bit number</th>
<th>Mask</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSG_RTR</td>
<td>0</td>
<td>0x1</td>
<td>Receive RTR or non-RTR messages</td>
</tr>
<tr>
<td>MSG_EXT</td>
<td>2</td>
<td>0x4</td>
<td>Receive extended/standard messages</td>
</tr>
<tr>
<td>MSG_LOCAL</td>
<td>3</td>
<td>0x8</td>
<td>Receive local or external messages</td>
</tr>
<tr>
<td>MSG_RTR_MASK</td>
<td>8</td>
<td>0x100</td>
<td>Take care about MSG_RTR bit else RTR and non-RTR messages are accepted</td>
</tr>
<tr>
<td>MSG_EXT_MASK</td>
<td>10</td>
<td>0x400</td>
<td>Take care about MSG_EXT bit else extended and standard messages are accepted</td>
</tr>
<tr>
<td>MSG_LOCAL_MASK</td>
<td>11</td>
<td>0x800</td>
<td>Take care about MSG_LOCAL bit else both local and external messages are accepted</td>
</tr>
<tr>
<td>MSG_PROCESSLOCAL</td>
<td>9</td>
<td>0x200</td>
<td>Enable processing of the local messages if not explicitly enabled globally or disabled globally</td>
</tr>
</tbody>
</table>

-w --wait
The number of second the `readburst` waits in the `select` call.

-p --prefix
The `prefix` string can is added at beginning of each printed line. The format specifies `%s` could be used to add device name into prefix.

-V --version
Print command version.

-h --help
Print command usage information

**sendburst**

**Name**
`sendburst` — the utility for continuous messages reception and printing of the message contents

**Synopsis**
**Description**

The utility **sendburst** generates blocks of messages with specified CAN message ID. The burst block of `blocksize` messages is generated and pushed into can device. If `count` is specified, the command stops and exits after `count` of message blocks send.

**OPTIONS**

- `-d --device`
  This option selects **sendburst** target CAN device. If the option is not specified, default device name `/dev/can0` is used.

- `-i --id`
  This option specifies which CAN message ID is used for transmitted blocks of messages. Hexadecimal value has to be prefixed by prefix `0x`. Numeric value without any prefix is considered as decimal one.

- `-f --flags`
  Specification of modifiers flags of the send message. Hexadecimal value has to be prefixed by prefix `0x`. Numeric value without prefix is considered as decimal one.

<table>
<thead>
<tr>
<th>Bit name</th>
<th>Bit number</th>
<th>Mask</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSG_RTR</td>
<td>0</td>
<td>0x1</td>
<td>Generate RTR messages if specified</td>
</tr>
<tr>
<td>MSG_EXT</td>
<td>2</td>
<td>0x4</td>
<td>Use extended messages identifiers if specified</td>
</tr>
</tbody>
</table>

- `-s --sync`
  Open device in the synchronous mode. The `send` and `close` blocks until message is sent to CAN bus.

- `-w --wait`
  The number of second the **sendburst** waits between sending burst blocks.

- `-b --block`
  The number of messages in the one burst block. Default value is 10.

- `-c --count`
  The number of block send after command invocation. If specified, command finishes and returns after specified number of blocks. If unspecified, the **sendburst** runs for infinite time.

- `-p --prefix`
  The `prefix` string can is added at beginning of each printed line. The format specifies `%s` could be used to add device name into prefix.

- `-V --version`
  Print command version.

- `-h --help`
  Print command usage information.