ATM Networking in Linux

Bindings occur at four distinct times:

- System initialization
- Device driver initialization
- Socket creation
- Socket connection

System initialization time:

Protocols known to linux are declared in a static table in module *protocols.c*

```
struct net_proto protocols[] = {
   { "UNIX",      unix_proto_init   },
   { "802.2",     p8022_proto_init },
   { "802.2TR",   p8022tr_proto_init },
   { "SNAP",      snap_proto_init },
   { "RIF",       rif_init },
   { "AX.25",     ax25_proto_init },
   { "NET/ROM",   nr_proto_init },
   { "INET",      inet_proto_init   },
   { "IPX",       ipx_proto_init },
   { "DDP",       atalk_proto_init },
   { "ATMPVC",    atmpvc_proto_init },
   { "ATMSVC",    atmsvc_proto_init },
   { NULL,         NULL     }
};
```

Protcol initialization modules are called in Linux kernel initialization.

ATMPVC initialization: `atmpvc_proto_init`

Its function is to register the protocol using the following call:

```
sock_register(pvc_proto_ops.family,
                              &pvc_proto_ops);
```

Family is `PF_ATMPVC (as in PF_INET)`
`pvc_proto_ops` is a table of entry point addresses:

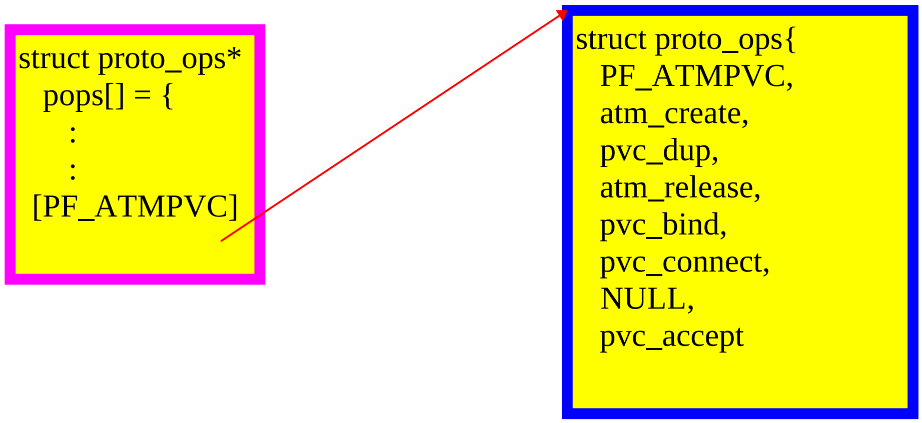
```
struct proto_ops {
  int family;
  int (*create)   (struct socket *sock, int protocol);
  int (*dup)      (struct socket *newsock, struct socket *old);
  int (*release)  (struct socket *sock, struct socket *peer);
  int (*bind)     (struct socket *sock, struct sockaddr *myad,
     :                 int sockaddr_len);
     :
```

For ATM PVCs the structure is filled in as follows:

```
static struct proto_ops pvc_proto_ops = {
   PF_ATMPVC,
   atm_create,
   pvc_dup,
   atm_release,
   pvc_bind,
   pvc_connect,
     :
```

- The entry point addresses are positionally standard for all protocols
- `sock_register()` saves the address of each protocol's proto_ops table in the `pops[]` table
- The `pops[]` table is indexed by `PF_number`

After protocol initialization



Generic Linux Networking
Linux ATM Networking
APE 25 Device Driver

Device driver initialization time:

From `init_module()` the driver must call

```
struct atm_dev *atm_dev_register(char *type,
                          struct atmdev_ops *ops,
                          unsigned long flags)
```

The first parameter is the device name .... “ape25”
The second is a pointer to the device driver operations vector table:

```
static struct atmdev_ops atm_ops =
{
  ape25_open,             /* open          */
  ape25_close,            /* close         */
  ape25_ioctl,            /* ioctl         */
  ape25_getsockopt,       /* getsockopt    */
  ape25_setsockopt,       /* setsockopt    */
  ape25_send,             /* send          */
     :
     :
```

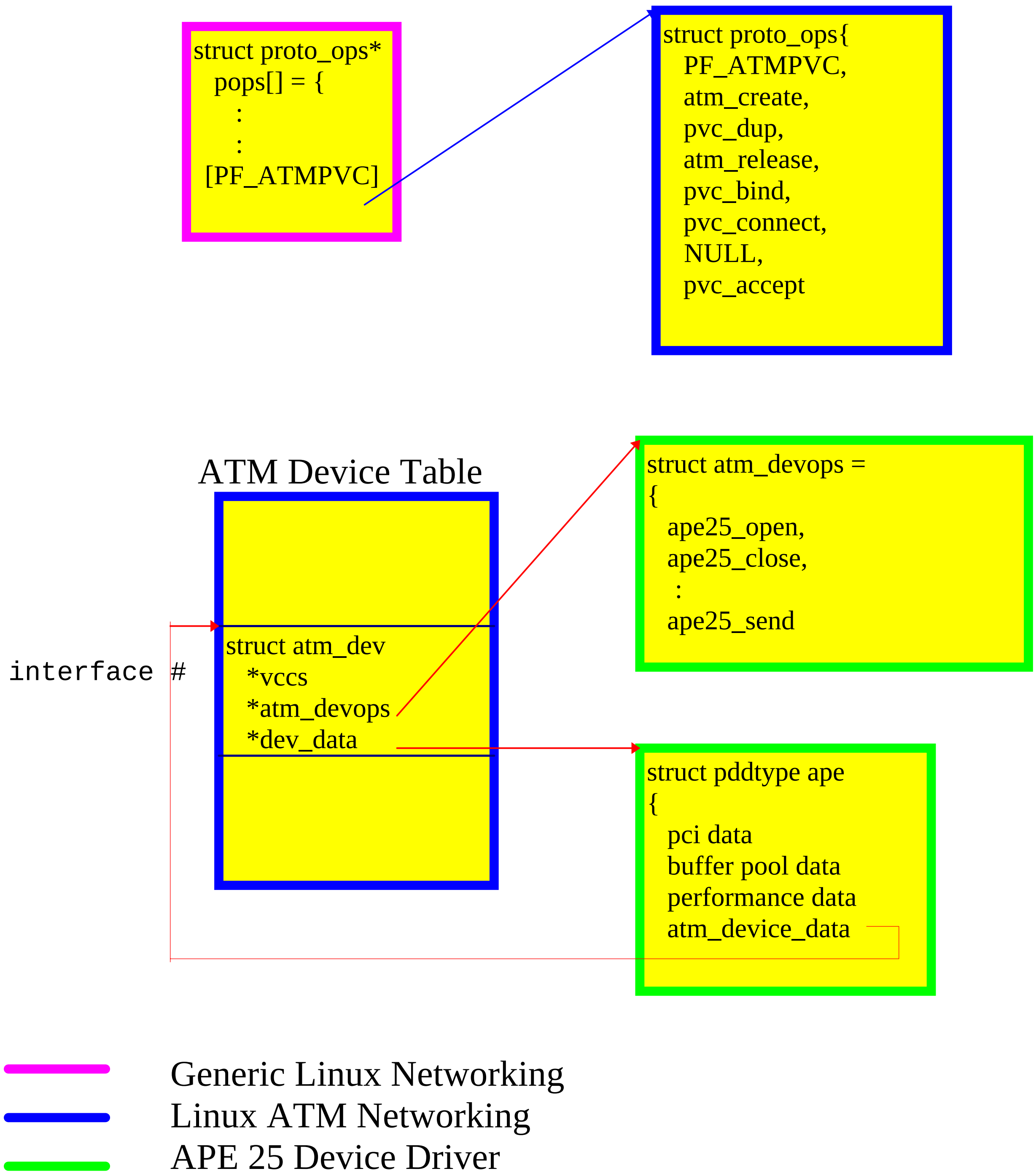
`atm_dev_register` allocates a slot in its ATM Device Table
Device table entries are structures of the following content:

```
struct atm_dev {
   const struct atmdev_ops *ops; /* device operations;       */
   const struct atmphy_ops *phy; /* PHY operations,          */
   const char   *type;           /* device type name         */
   int       number;             /* device index             */
   struct atm_vcc *vccs;         /* VCC table (or NULL)      */
   struct atm_vcc *last;         /* last VCC (or undefined)  */
   void     *dev_data;           /* per-device data          */
   void     *phy_data;           /* private PHY date         */
     :
};
```

A pointer to the atm_dev structure is returned to the driver, and the drivers “ape” structure and the atm_dev structure are linked.

```
ape->atmdev = atm_dev_register(.....);
ape->atmdev->dev_data = ape;
```

After Device Driver Initialization



Socket Creation Time

A socket is created with the usual call:

```
socket(int family, int type, int protocol)
```

For example:

```
s = socket(PF_ATMPVC,SOCK_DGRAM,ATM_AAL5);
```

A new socket structure is allocated:

```
struct socket {
   short               type;    /* SOCK_STREAM, ...            */
   socket_state        state;
   long                flags;
   struct proto_ops    *ops;   /* protocols do most everything */
   void                *data;  /* protocol data (-> atmvcc)    */
   struct socket       *conn;  /* server socket connected to   */
   struct socket       *iconn; /* incomplete client conn.s     */
   struct socket       *next;
   struct wait_queue   **wait; /* ptr to place to wait on      */
   struct inode        *inode;
   struct fasync_struct *fasync_list; /* Asynch wake up list  */
   struct file        *file;   /* File back pointer for gc     */
 }
```

The ATM protocol operations table pointer
retrieved from `pops[PF_ATMPVC]`
and stored in the socket structure

The protocol specific (atm_create) create function is then called.

ATM Socket Creation

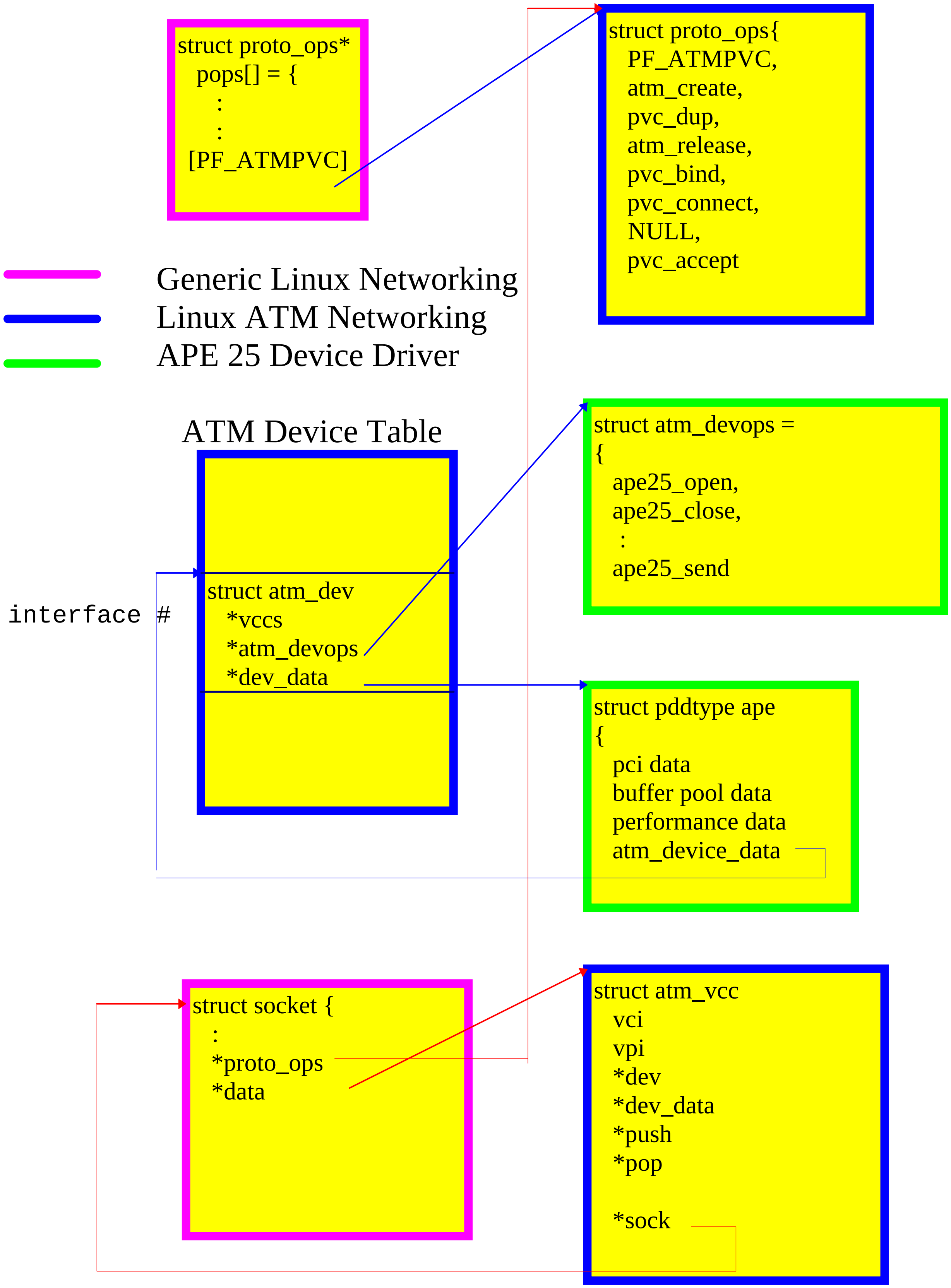
`atm_create` allocates a *VCC* structure

```
struct atm_vcc {
   unsigned short flags;      /* VCC flags (ATM_VF_*)        */
   unsigned char  family;     /* address family; 0 if unused */
   unsigned char  aal;        /* ATM Adaption Layer          */
   short    vpi;              /* VPI and VCI (types must be  */
                              /* equal with sockaddr)        */
   int      vci;
   unsigned long  aal_options;   /* AAL layer options        */
   unsigned long  atm_options;   /* ATM layer options        */
   struct atm_dev *dev;       /* device back pointer         */
   struct atm_qos qos;        /* QOS                         */
   unsigned long  tx_quota,rx_quota; /* buffer quotas        */
   atomic_t tx_inuse,rx_inuse;       /* buffer space in use  */

   void (*push)(struct atm_vcc *vcc,struct sk_buff *skb);
   void (*pop)(struct atm_vcc *vcc,struct sk_buff *skb);
     :
     :
   void     *dev_data;          /* per-device data           */
   void     *proto_data;        /* per-protocol data         */
   struct timeval timestamp;    /* AAL timestamps            */
   struct sk_buff_head recvq;   /* receive queue             */
     :
   struct socket  *sock;        /* Back pointer to our socket */
     :
}
```

atm_create then

- Cross links the vcc and socket structures using the `*sock` field in the vcc and the `*data` field in the socket.
- Initializes some required fields in the vcc.

After socket creation



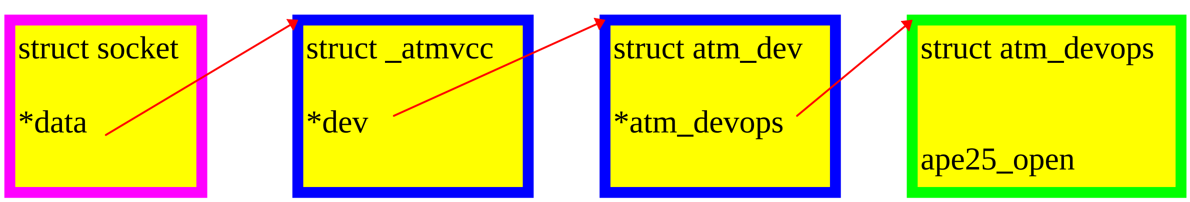
Connect time

Connect is called as follows:

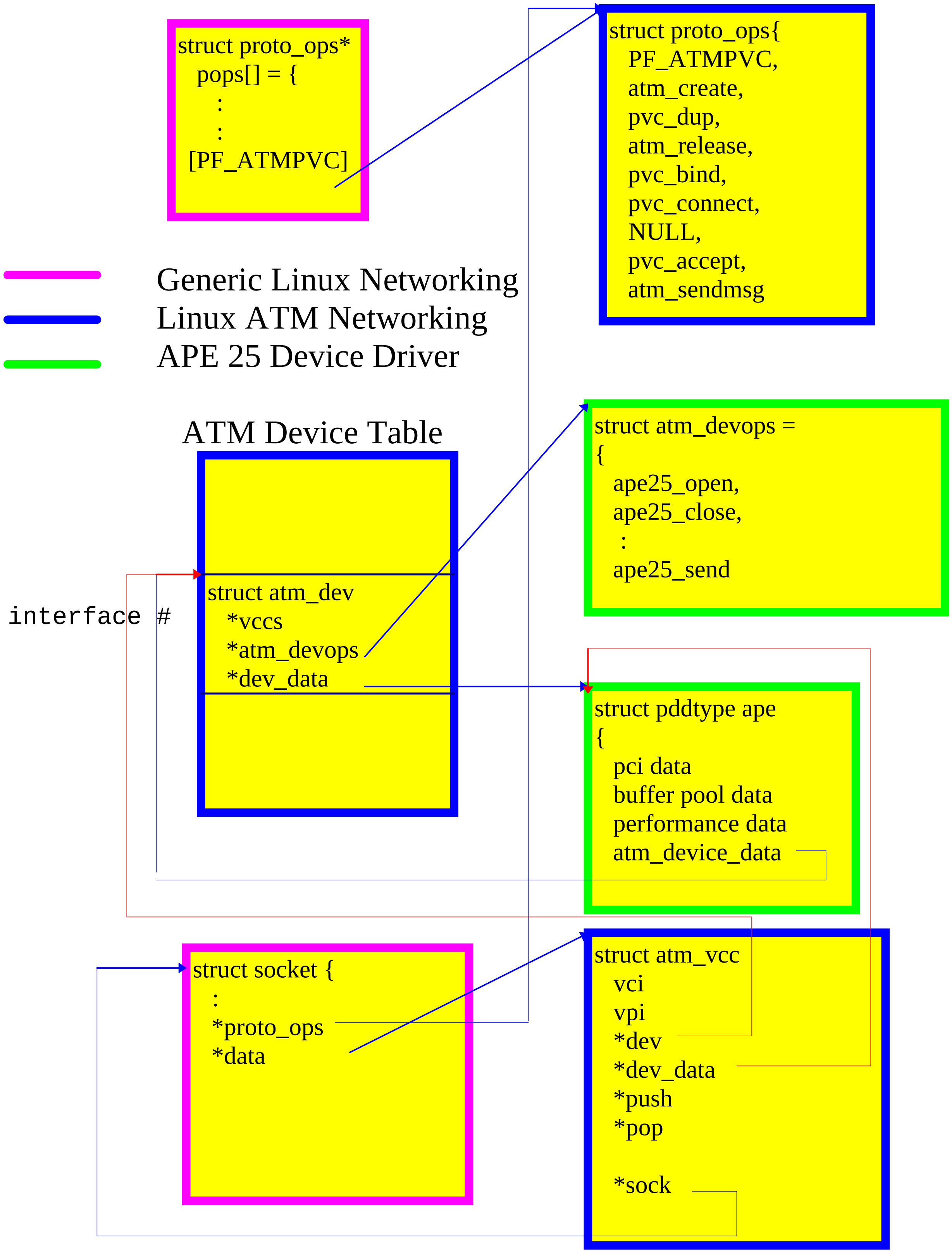
```
struct sockaddr_atmpvc addr;

addr.sap_family   = AF_ATMPVC;
addr.sap_addr.itf = 0;
addr.sap_addr.vpi = 0;
addr.sap_addr.vci = 33;
rc = connect(s,(struct sockaddr *) &addr,
             sizeof(addr));
```

Internally within the generic connect system call

- The socket structure is recovered using the handle s
- The socket structure contains the proto_ops table pointer.
- The address of the routine atm_do_connect is found in that table
- atm_do_connect uses the interface number as an index in the atm_dev table where it finds pointers to driver data structures
- it copies the drivers device descriptor to the vcc structure
- it invokes the driver's ape25_open function through the driver's dev_ops table



After Connection

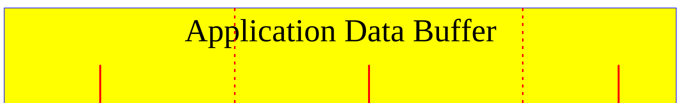


Device Driver Support for the Linux ATM Stack

Transmit buffer management

When an application calls..........

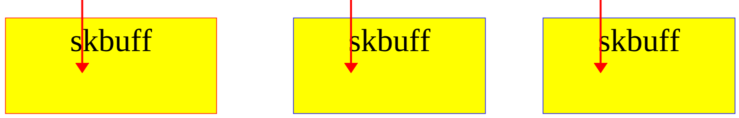
```
write(sock, buf, sizeof(buff));
```



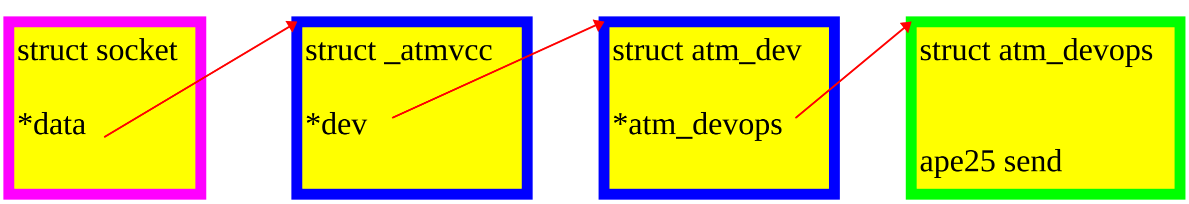
- `sys_write` determines this request is a socket write
- Socket structure contains a point to the ATM pvc `proto_ops`
- The proto_ops table points to `atm_sendmsg`

`atm_sendmsg`

- acquires skbuff(s) in kernel space and copies the message



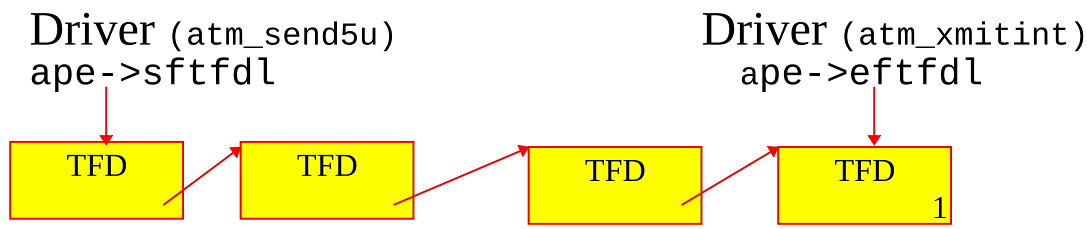
- acquires the address of the driver send routine



ape25_send

- Parameters
  -> skbuff
  -> vcc structure
- Recovers pointer to “ape” structure from vcc->dev_data
- Invokes `atm_send5skb` in atmxmit.c

atm_send5skb



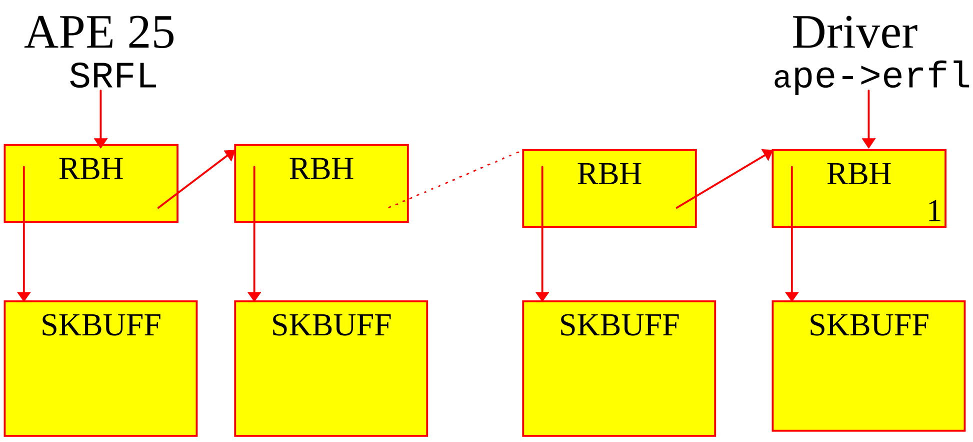
- Recovers a free TFD from the driver maintained free list
- Binds the skbuff to the TFD
- Stores the vcc address in an extension to the TFD
- Initiates the transmission.

atm_xmitint

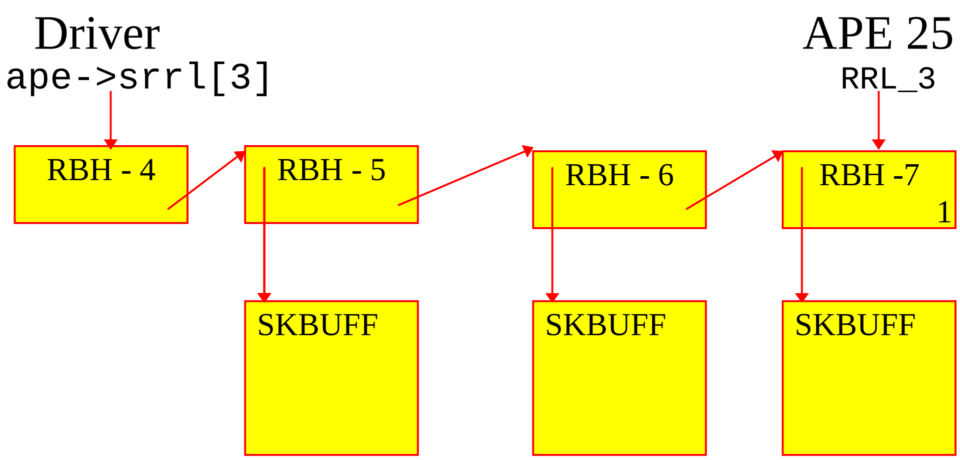
- Removes TFD from the TCL as before
- Recovers vcc pointer from the TFD extension
- Calls the “pop” routine pointed to by the vcc to free the skbuff

Receive buffer management

- During initialization the driver allocates and binds skbuffs to the RBHs on the free list



- During interrupt service the driver processes the Receive ready lists



- RBH’s (4, 5, and 6) are returned to the free RBH list

- The LC value in the RBH is used to recover the VCC address from a table entry that is made at VCC open time.

- The address of the “push” routine in the VCC is used to forward the buffer to the protocol.

Free buffer list replenishment

- The Linux ATM protocol supports

    Driver managed receive skbuffs
    Protocol managed receive skbuffs

- The APE 25 driver implements *driver managed skbuffs* and exports `ape25_free_rx_skb` in its atm_devops table

- The protocol calls `ape25_free_rx_skb` when the data in a receive buffer has been consumed.

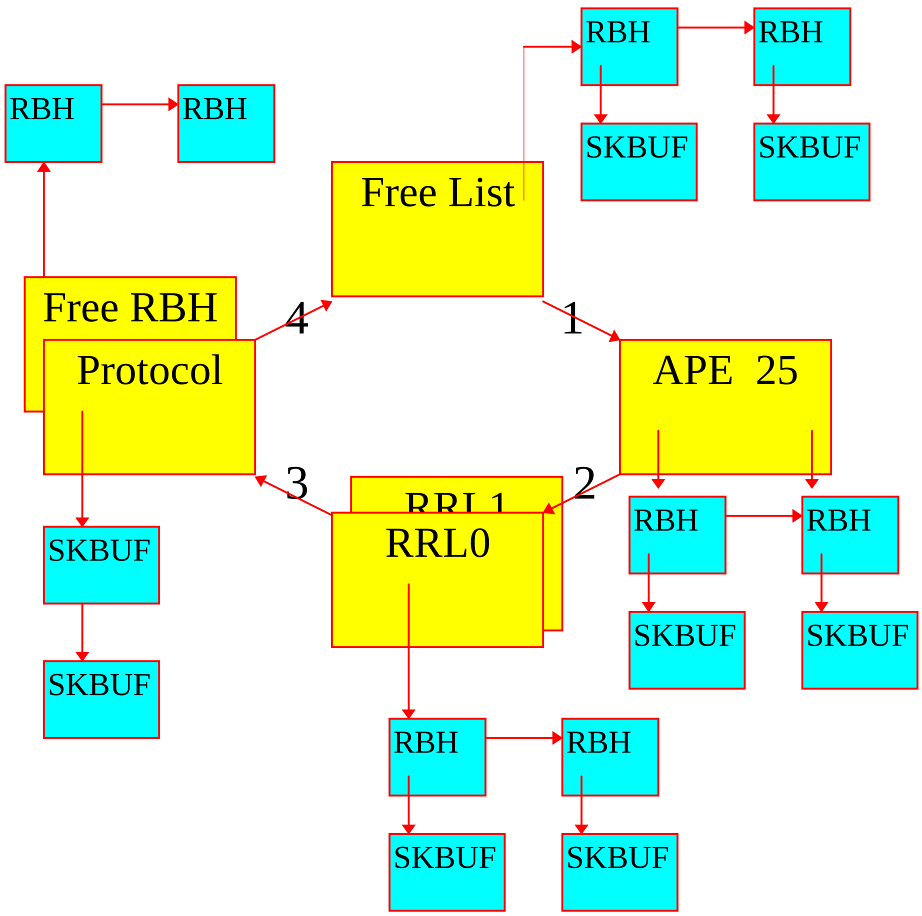
`ape25_free_rx_skb`

- Dequeues a free RBH from the free rbh list
- Binds the RBH to the skbuff being freed
- Adds the RBH to the RFL for use by the APE 25.

Recovery from lost skbuffs

- The protocol doesn't --always-- return the skbuffs.
- The driver keeps a count of *free* RBH's.
- Free RBH count too *high* -> lost skbuffs.
- The driver replenishes the supply via alloc_skb

Reviewing the buffer lifecycle



1 - APE 25 consumes a RBH-SKBUFF via the `SRFL` register

2 - APE 25 produces on to `RRL_n` via the `RRLn_LFDA` register

3 - Driver (interrupt service routine) consumes from `RRL_n` via `ape->srrl[n].` RBH is produced to free RBH list. Skbuff is "pushed" to protocol.

4 - Protocol returns skbuff to driver. Driver consumes RBH from free RBH list and produces matched pair to the free list via `ape->erfl.`