Programming with the Netpoll API

Linux Kongress 2005

Jeff Moyer **<jmoyer@redhat.com>**

Senior Software Engineer

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Contents

- Netpoll and its origins
- Network driver primer
- Netpoll inner-workings
- Quick-start guide to the API
- Extending netconsole
- Moving forward

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Netpoll Origins

- 2.4 kernel crash dump solution – netdump (Ingo Molnar)
  - netdump
  - remote syslog
  - netlog / netconsole
- Requirements
  - send / receive packets when kernel is crashed
  - send out log messages from interrupt context
- 2.6 – core architecture abstracted and generic API created (Matt Mackall)
  - kgdb support added

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The Netpoll API

API which provides a means for implementing UDP clients and servers in the kernel.

- Operates *mostly* independently from the core network stack
- Used by “applications” which require network communications when the system is quiesced
  - netconsole
  - kgdb
  - netdump
- Each netpoll client describes a single connection (src/dst ip:port)

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Network Driver Primer

- Sending packets: `hard_start_xmit`
  - When is it safe to call?
    - irqs *enabled*, bh's disabled
    - `dev->xmit_lock` held
    - `netif_queue_stopped` returns false (0)
- Device Output Queue
  - netif_stop_queue
    - out of TX descriptors
    - link down event
    - driver unload

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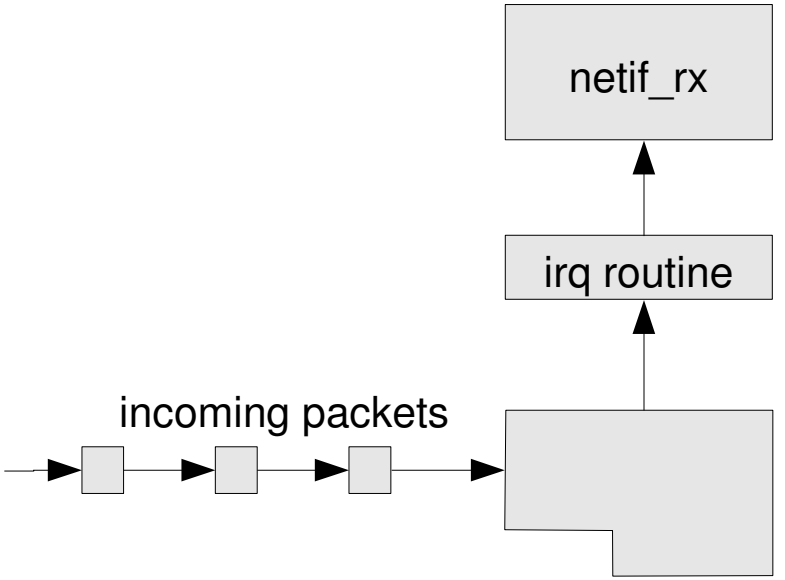
Network Driver Primer (cont'd)

- netif_wake_queue
  - TX descriptors back to a sane level
  - link up event
- netif_queue_stopped
  - boolean test

Receiving Packets

- Interrupt routine
  - Process and ACK interrupts (duh!)
  - Schedule packets for delivery to the network stack
  - Clean up any free RX or TX descriptors*



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The New API

- Theory of operation
  - Faster network adapters cause many interrupts
    - Interrupts are bad, mm'kay?
    - Switch to polling mode until the “storm” passes

- Polling loop
  - NAPI polls are scheduled for the CPU on which the interrupt was received
  - Only one CPU can execute the poll routine at a time, and it is **not** reentrant!
  - Each interface is given a budget, whose default is set in the driver code (device weight)

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Receiving Packets with NAPI

- Interrupt routine:
  - Process and ACK interrupts
  - Disable interrupts on this device
  - Schedule a NAPI poll if necessary
- `net_rx_action` (network bh handler) calls the NAPI poll routine, which:
  - delivers the packet to the net stack
  - cleans up any free RX or TX descriptors*
- Interrupts are re-enabled when the device has no more pending work

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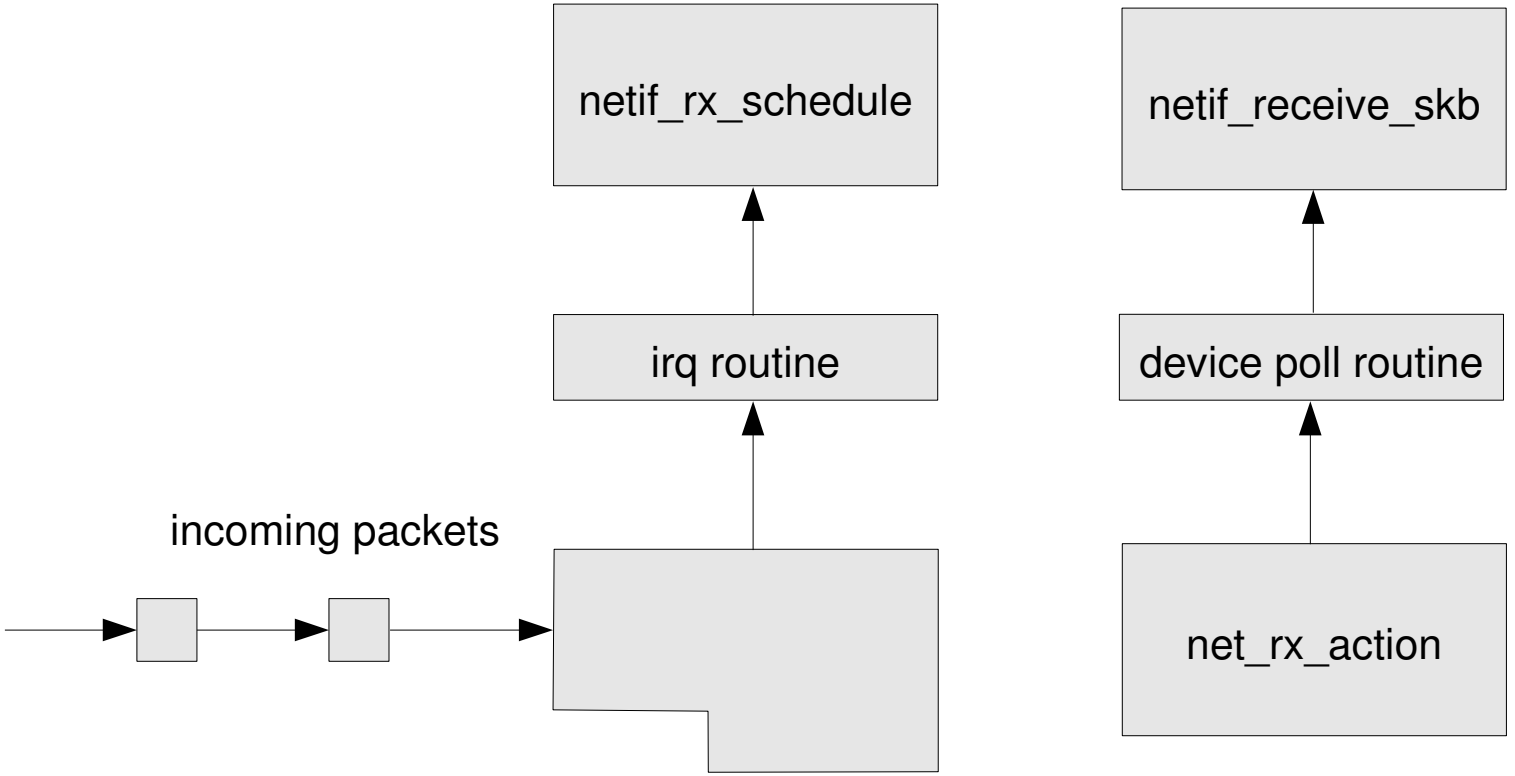
Receiving Packets (NAPI)



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Netpoll

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Netpoll Implementation

- Driver Hooks
- Polling
- Sending Packets
  - Real network device
  - Bonded network device
- What to do when polling fails
- Receiving Packets

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Netpoll – Driver Interface

- Polling mode
  - needs to work with irq's disabled
  - needs to work when the system is crashed
  - requires special hook(s) in network drivers

- Typical `poll_controller` hook:

```
static void tg3_poll_controller(struct net_device *dev)
{
     struct tg3 *tp = netdev_priv(dev);
     tg3_interrupt(tp->pdev->irq, dev, NULL);
}
```

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Sending Packets

- API Routine: `netpoll_send_udp`
  - Directly calls driver's `hard_start_xmit` routine

- Needs to handle the `netif_queue_stopped` case
  - `dev->poll_controller`
  - `poll_napi` (`dev->poll`)

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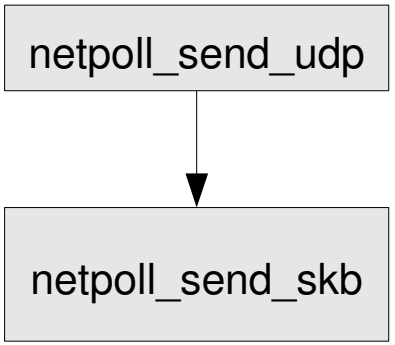
Sending Packets



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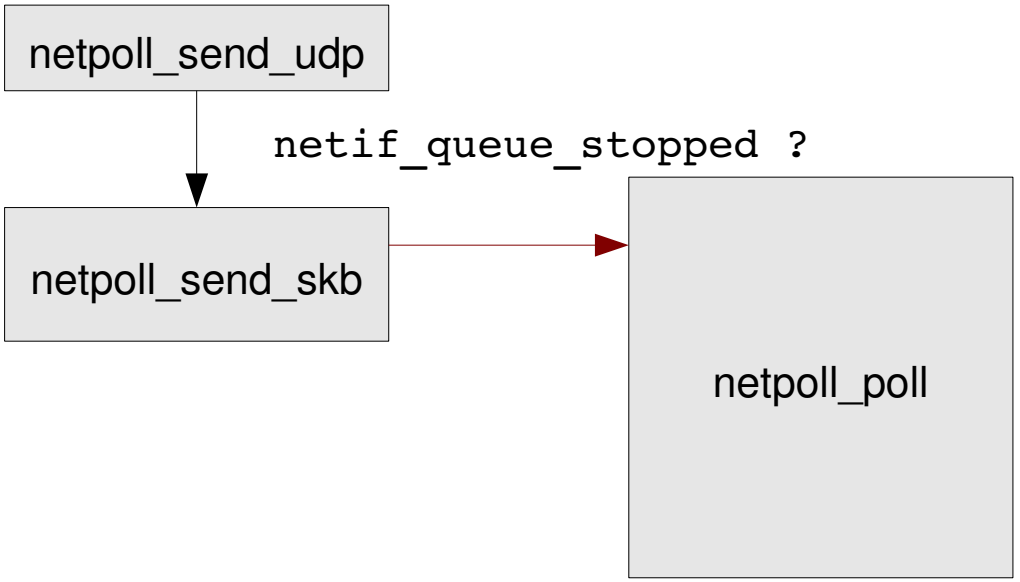

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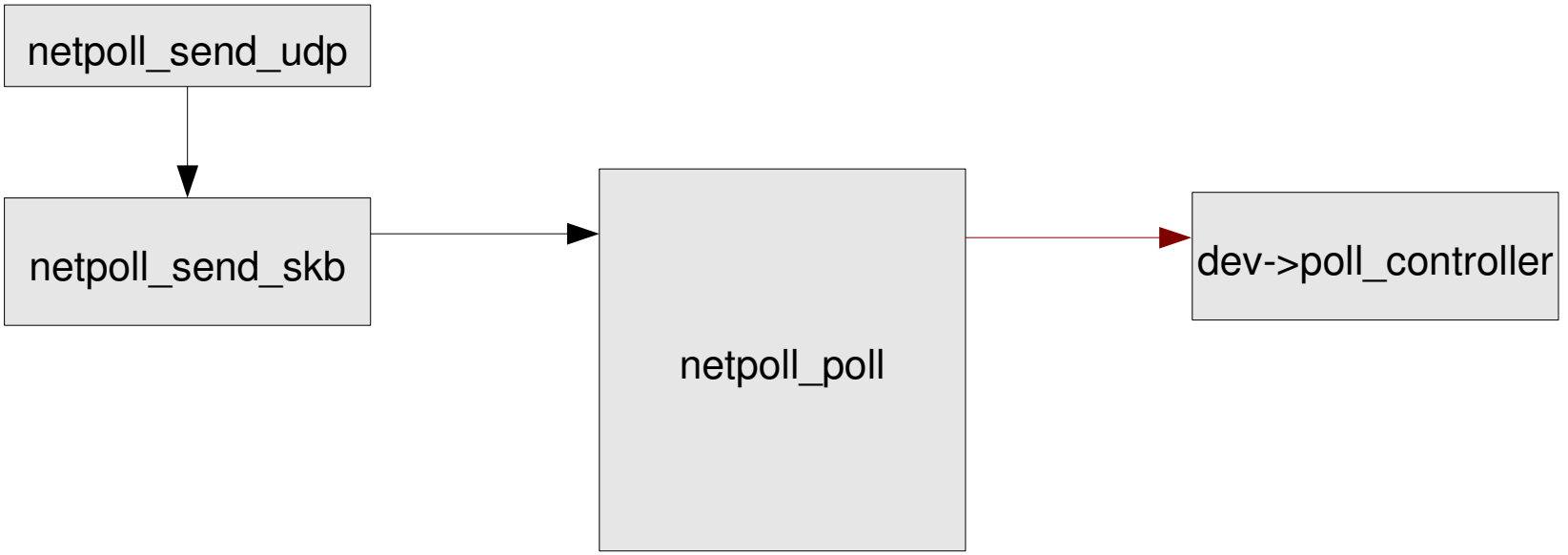

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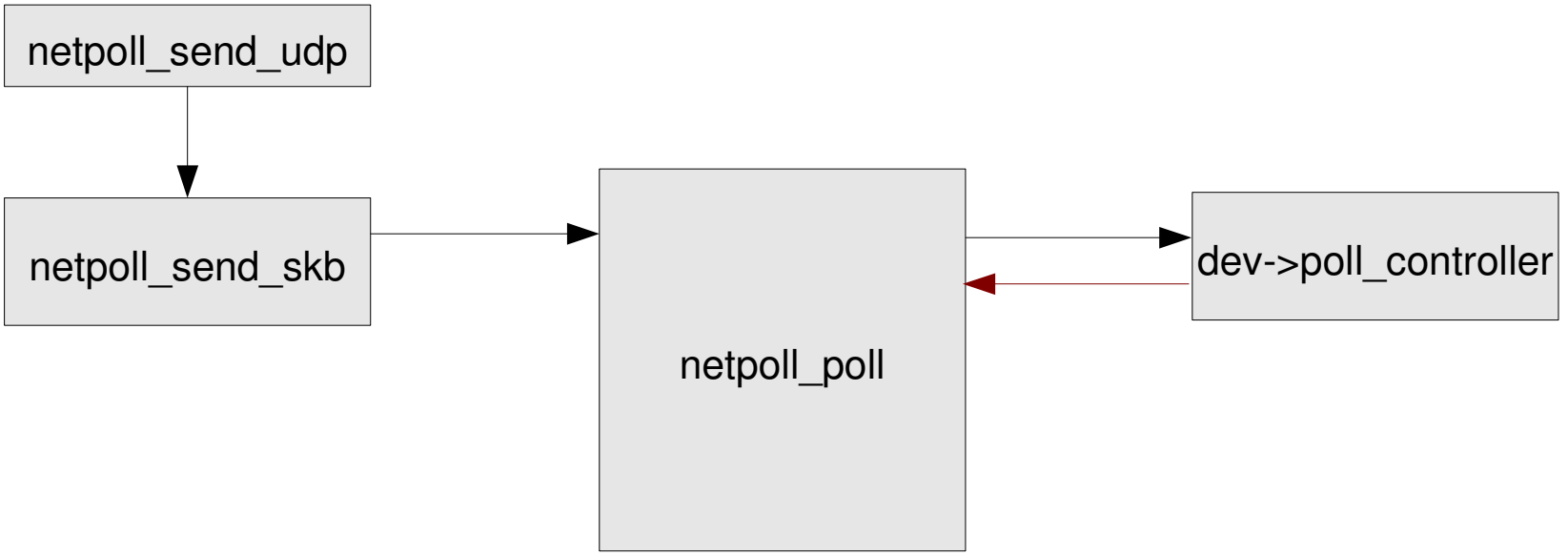

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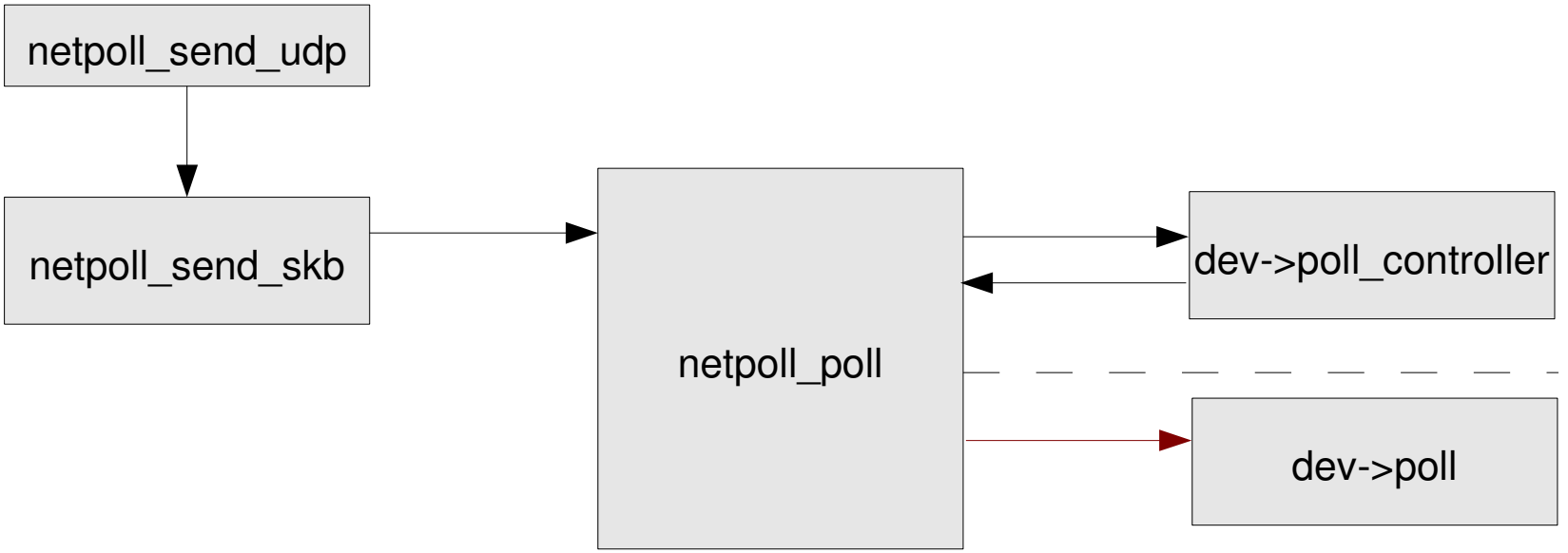

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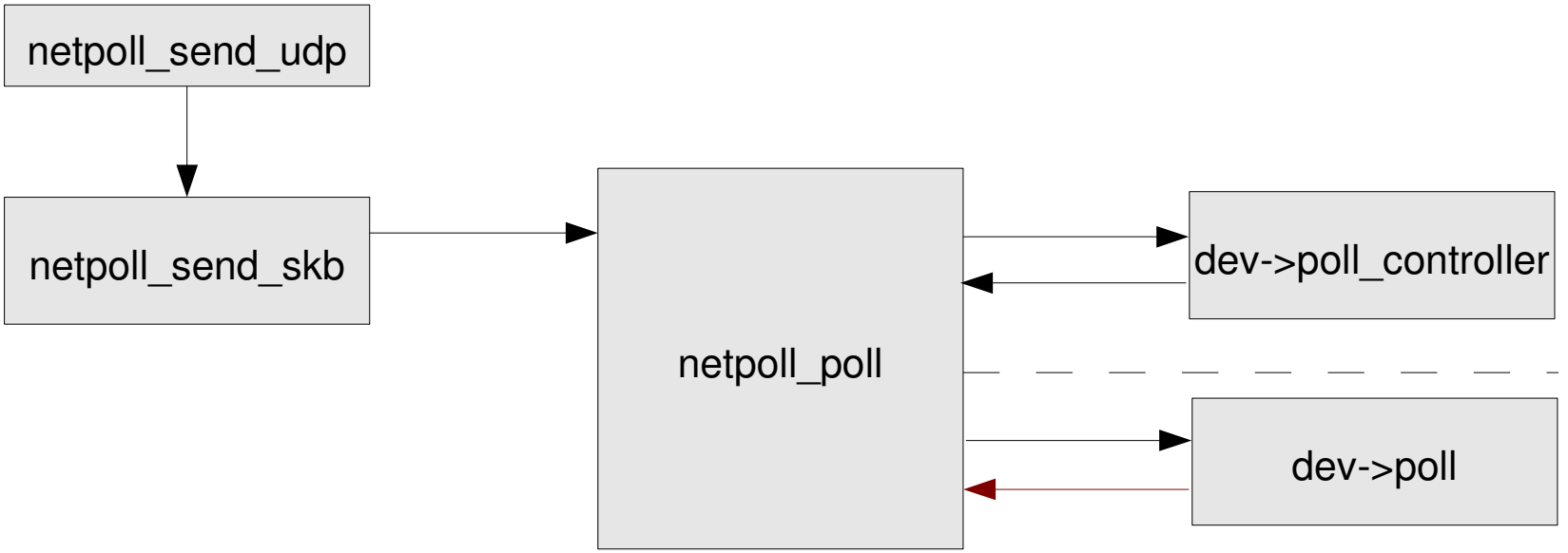

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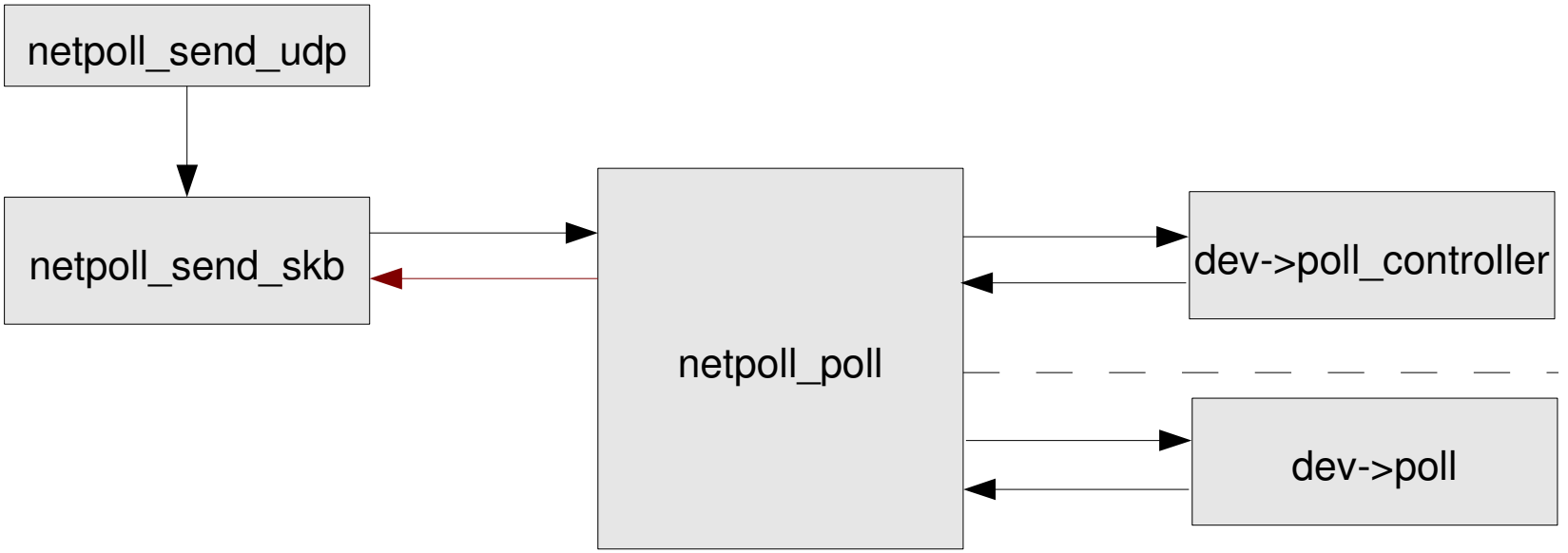

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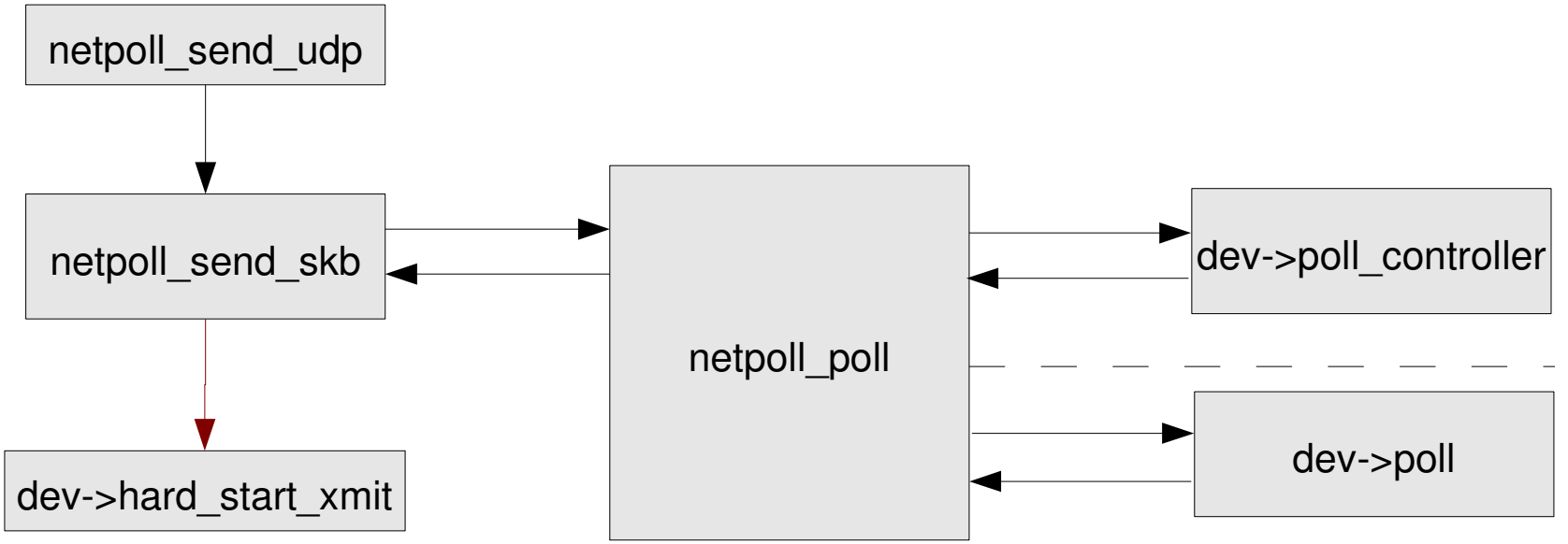
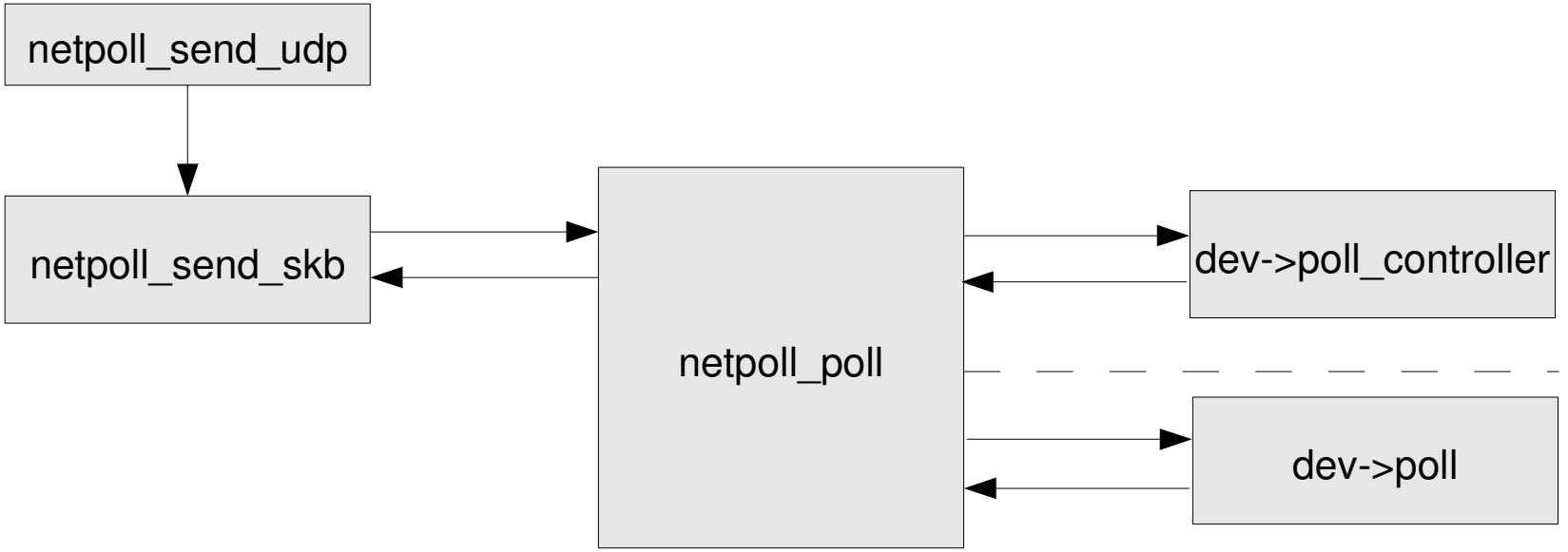


Sending Packets – Bonding Driver



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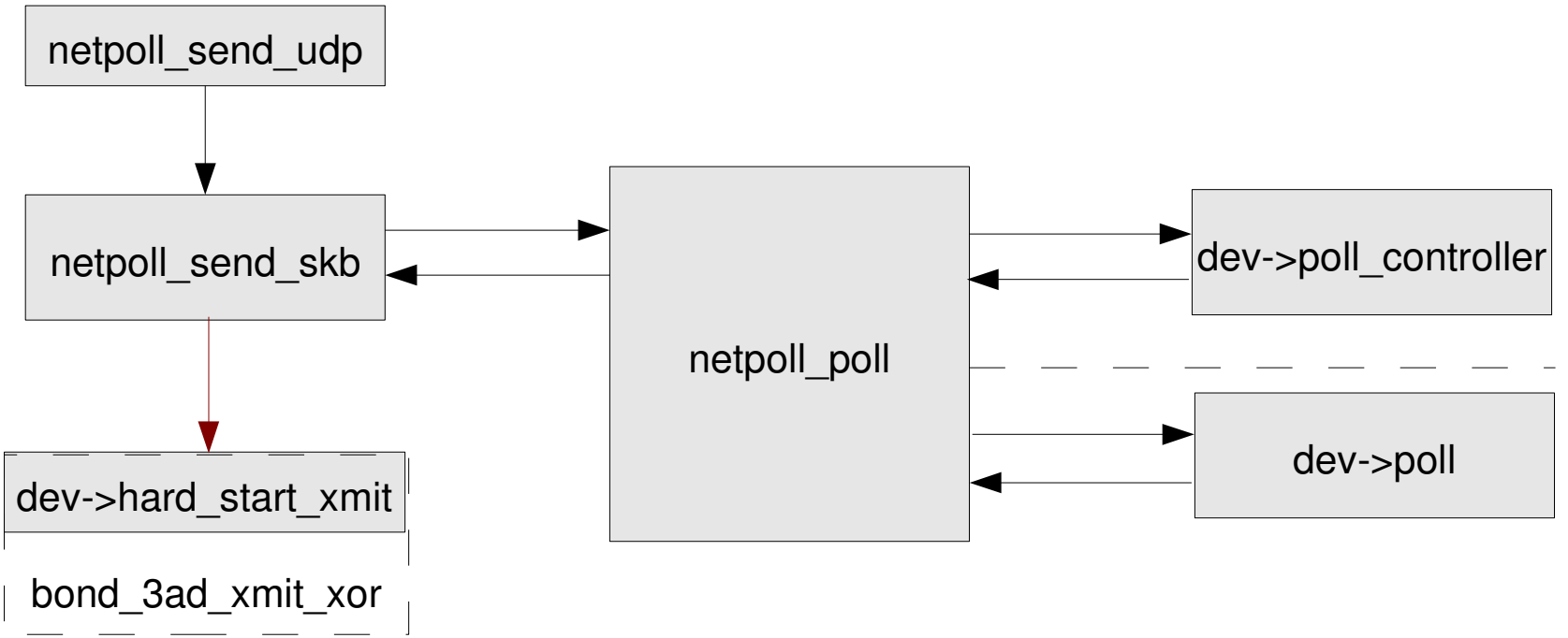

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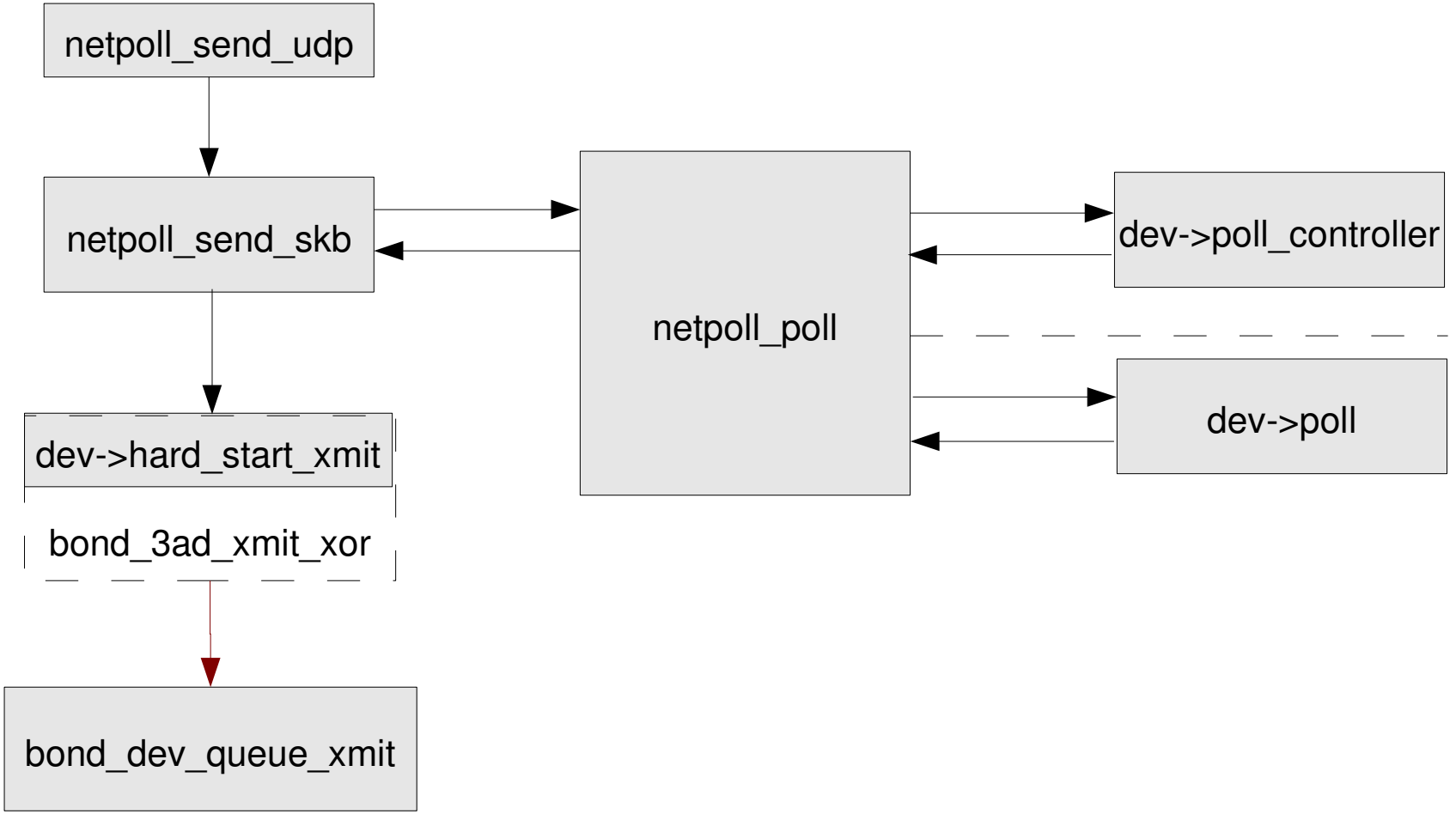

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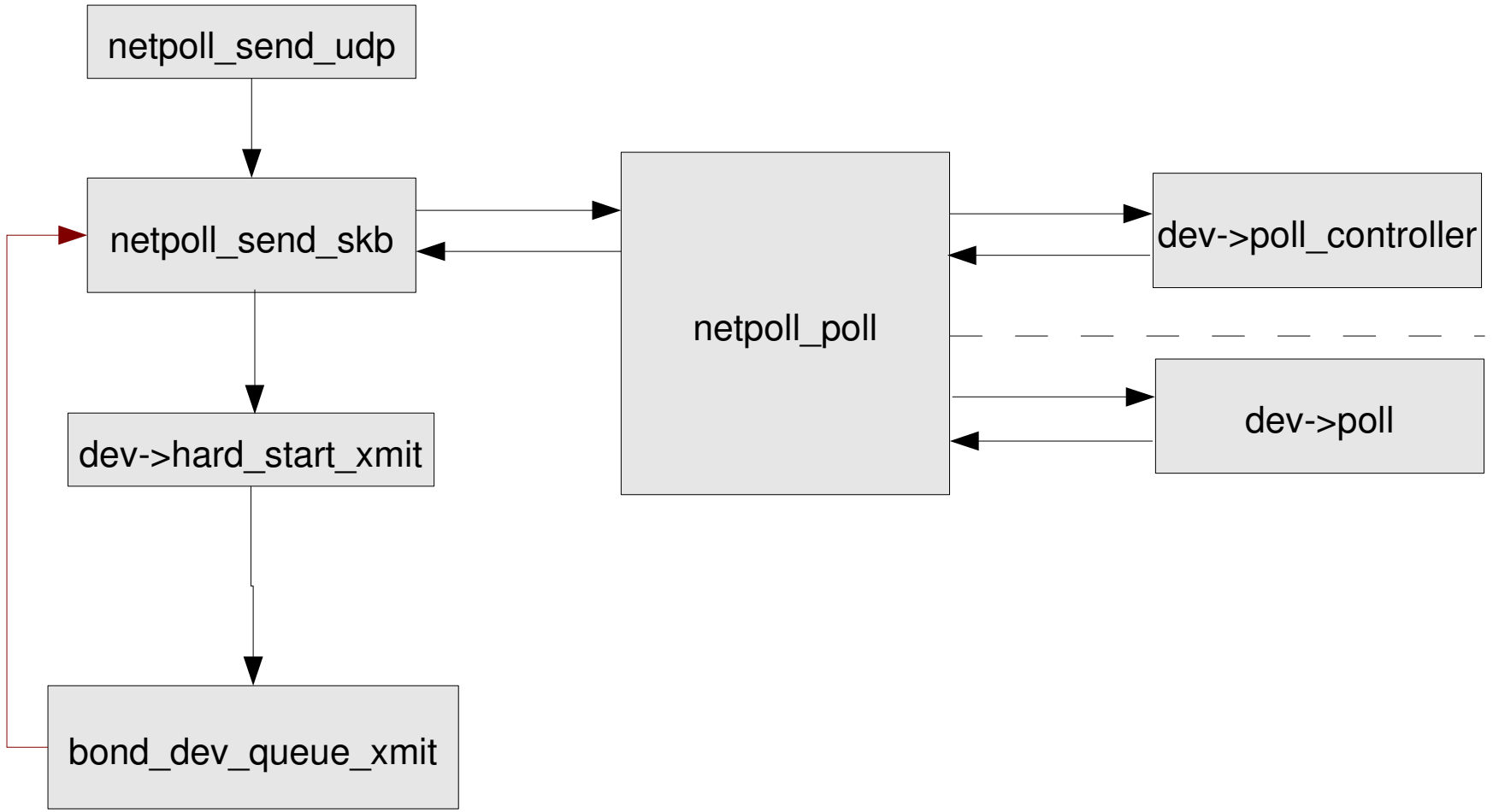

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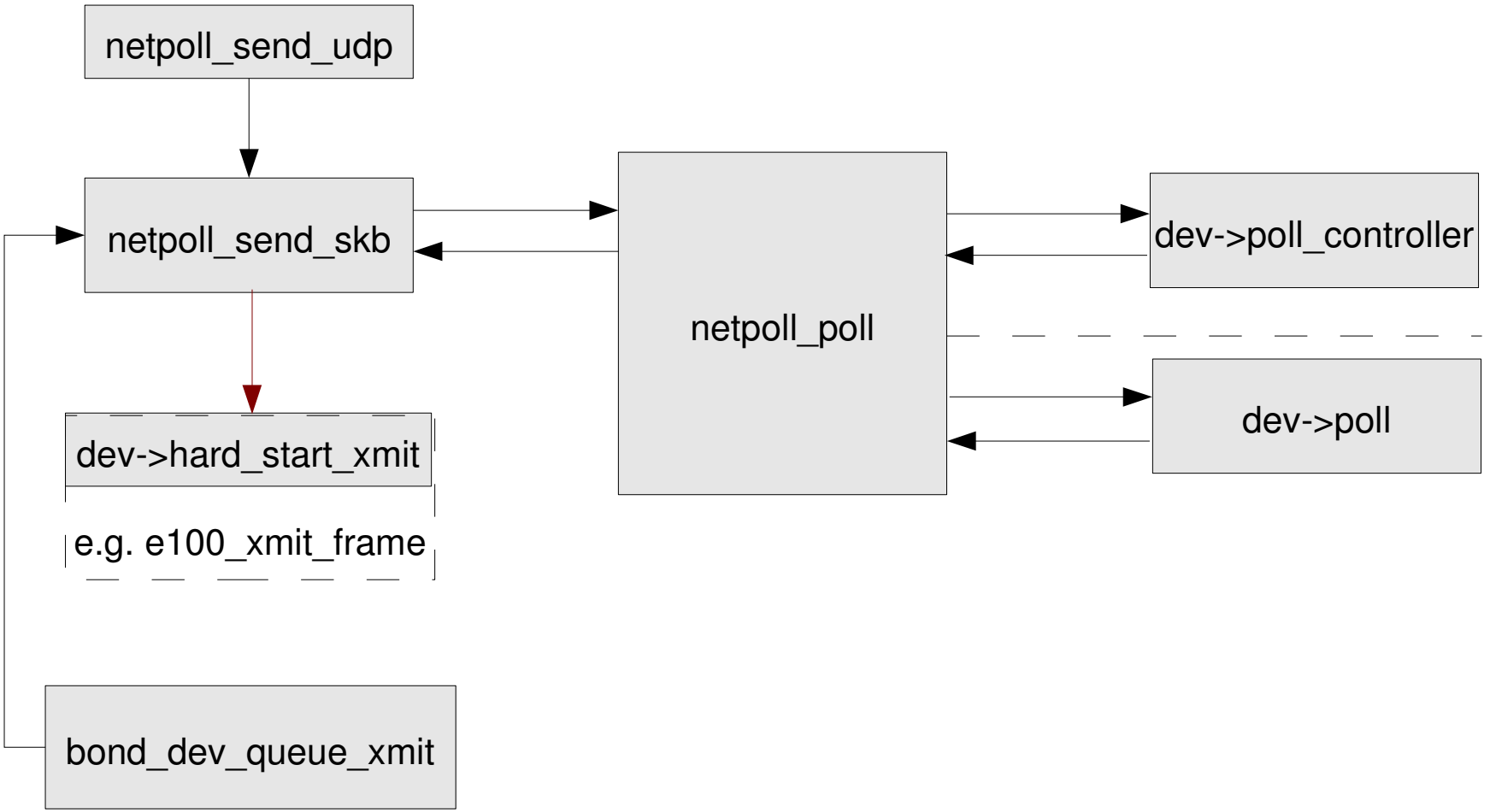

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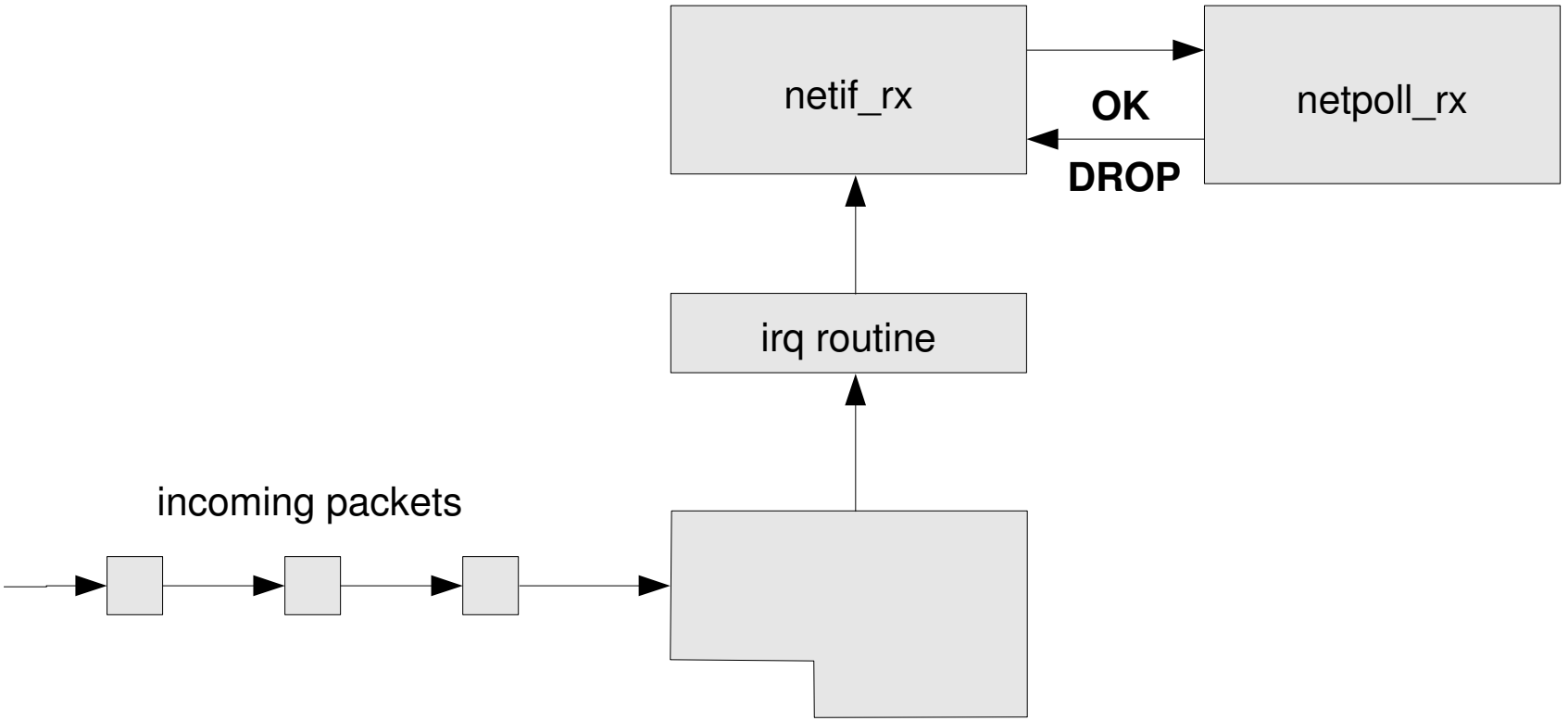
When Polling Fails...

- netif_queue_stopped returns true when:
  - no TX descriptors
  - **link is down**
- Sending packets synchronously can fail!
- Drop routine:
  - can do whatever the module author wants it to do
  - `netpoll_queue` is provided as a means to queue the packet for later delivery (in process context)
  - if not specified, the packet will be dropped

Receiving Packets (non-NAPI)



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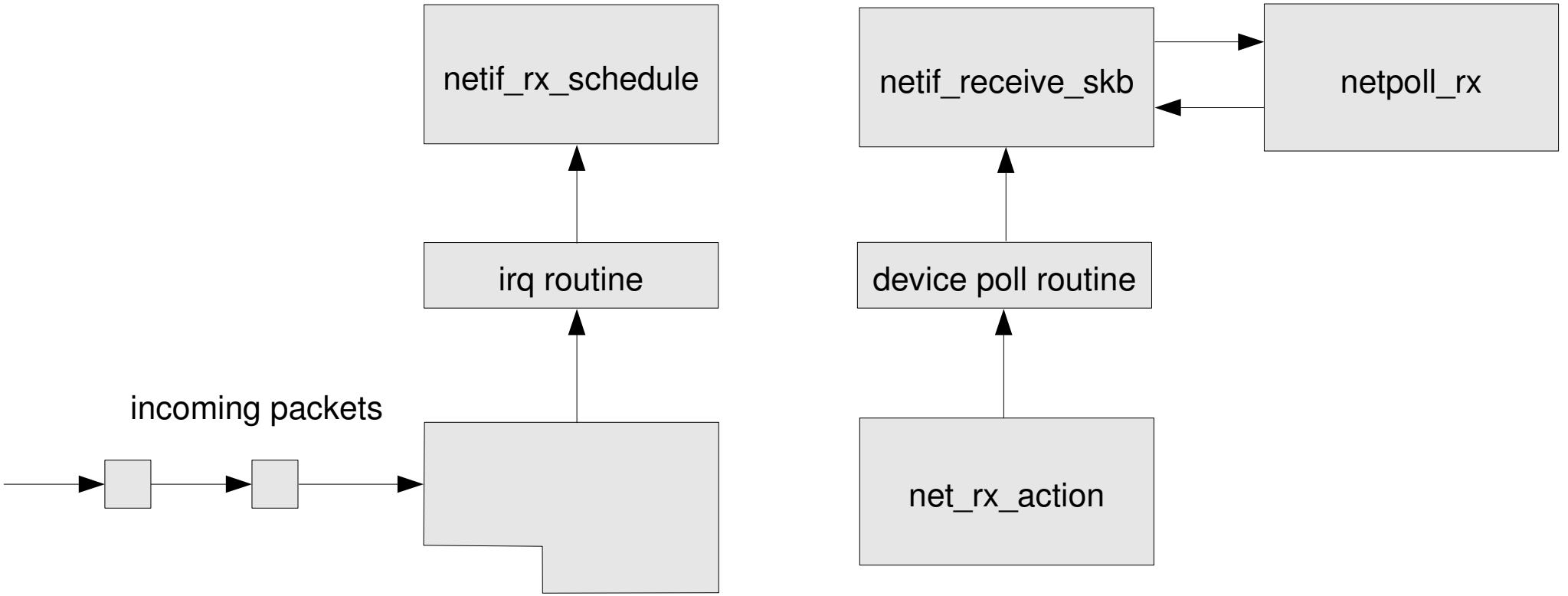
Receiving Packets (NAPI)



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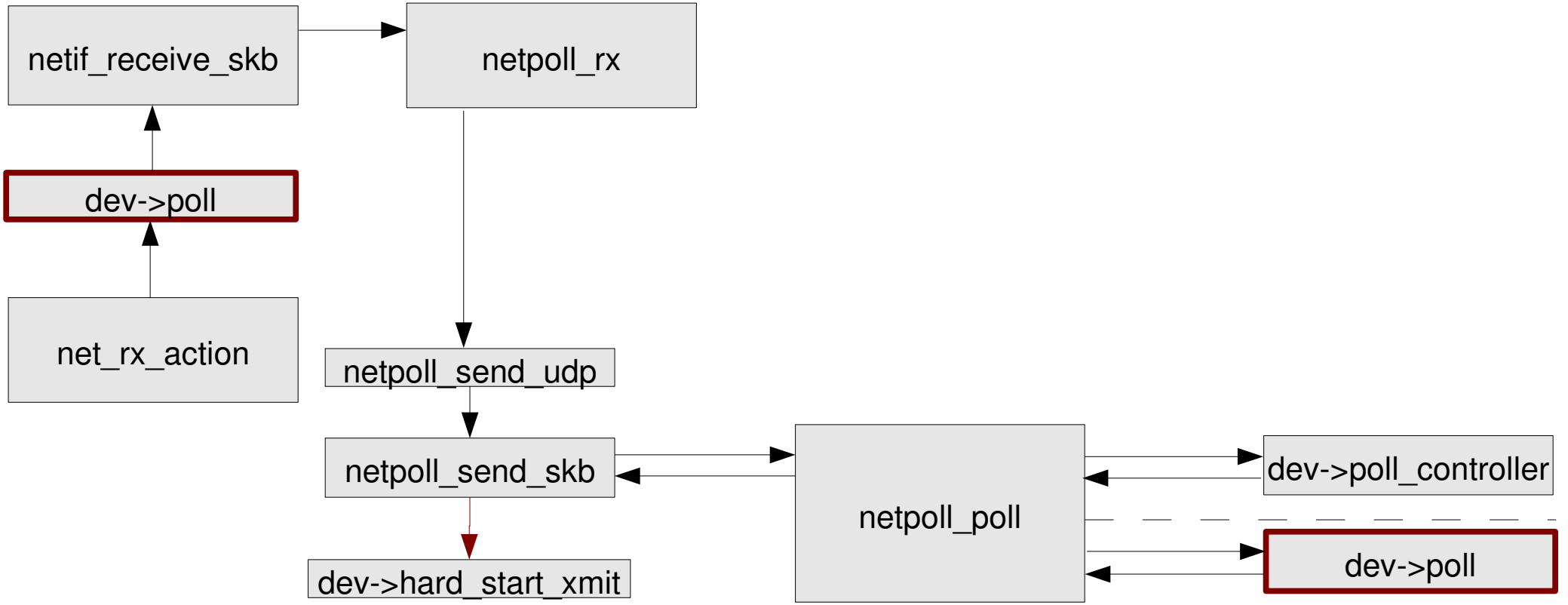
Sending Packets in the Receive Path



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Using the API

- Initialization
- Sending Packets
- Receiving Packets
- Specifying a *drop* routine

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Client Data Structure

```
struct netpoll {
    struct net_device *dev;
    char dev_name[16], *name;
    void (*rx_hook)(struct netpoll *, int, char *, int);
    void (*drop)(struct sk_buff *skb);
    u32 local_ip, remote_ip;
    u16 local_port, remote_port;
    unsigned char local_mac[6], remote_mac[6];
};
```

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Netpoll Module Initialization

```
int netpoll_parse_options(struct netpoll *np, char *opt);
```

np: struct netpoll with *name*, *drop*, and *rx_hook* filled in

opt: "[src-port]@[src-ip]/[dev],[tgt-port]@<tgt-ip>/[tgt-macaddr]"

Returns 0 on success, -1 on failure

```
int netpoll_setup(struct netpoll *np);
```

np: struct netpoll, initialized via a call to *netpoll_parse_options*

Returns: 0 on success, -1 on failure

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API – Sending & Receiving Packets

```
void netpoll_send_udp(struct netpoll *np, const char *msg, int len);
```

msg: byte stream to be sent

len: length of byte stream contained in *msg*

```
void rx_hook(struct netpoll *np, short source, char *data, int dlen);
```

data: contents of received packet; UDP headers stripped

dlen: length of *data*

Called in BH context for NAPI drivers, interrupt context for old drivers.

```
void drop(struct sk_buff *skb);
```

skb: socket buffer that could not be sent.

```
void netpoll_queue(struct sk_buff *skb);
```

queues the packet for later delivery, in process context

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Extending Netconsole

- Goals
  - allow remote user to issue sysrq commands via netconsole
- Non-goals
  - Support a full interactive console

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Extending Netconsole (cont'd)

```
static struct netpoll np = {
    .name = "netconsole",
    .dev_name = "eth0",
    .local_port = 6665,
    .remote_port = 6666,
    .remote_mac = {0xff, 0xff, 0xff, 0xff, 0xff, 0xff},
    .drop = netpoll_queue,
    .rx_hook = netconsole_rx;
};
void netconsole_rx(struct netpoll *nps, short source, char *data, int dlen)
{
    while (count < dlen) {
          if (data[count] < 'a' || data[count] > 'Z' ||
                    data[count] == '\n') {
                    count++;
                    continue;
          }
          handle_sysrq(msg->msg[count], NULL, NULL);
          count++;
    }
}
```

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Netpoll TODO

- Allow more than one netpoll client to register an rx hook
- Netpoll calls drivers in improper context
  - Implement separate hard_start_xmit routine for every network driver?
- Fix locking so that queuing is not necessary all of the time

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References

- netdev mailing list <netdev@vger.kernel.org>
- Linux kernel sources, versions 2.4 and 2.6 http://www.kernel.org/

- http://people.redhat.com/jmoyer/