e1000网卡收包callstack分析

```TXT
/**
 * netif_receive_skb_list - process many receive buffers from
network
 * @head: list of skbs to process.
 *
 * Since return value of netif_receive_skb() is normally
ignored, and
 * wouldn't be meaningful for a list, this function returns
void.
 *
 * This function may only be called from softirq context and
interrupts
 * should be enabled.
 */
```

`void netif_receive_skb_list(struct list_head *head)`: `drivers/net`实现各种硬件设备的驱动，收包后从硬件获取buffer，驱动代码中调用 `netif_receive_skb_list`进入内核网络系统，进行接下来的处理

驱动向内核注册softirq，里面包含回调函数。驱动收到数据触发中断，kernel读取

```c
__netif_receive_skb_list_ptype(struct net_device * orig_dev,
struct packet_type * pt_prev, struct list_head * head)
(/data00/codes/linux/net/core/dev.c:5533)
__netif_receive_skb_list_core(struct list_head * head, bool
pfmemalloc) (/data00/codes/linux/net/core/dev.c:5582)
__netif_receive_skb_list(struct list_head * head)
(/data00/codes/linux/net/core/dev.c:5634)
netif_receive_skb_list_internal(struct list_head * head)
(/data00/codes/linux/net/core/dev.c:5725)
gro_normal_list(struct napi_struct * napi)
(/data00/codes/linux/include/net/gro.h:433)
gro_normal_list(struct napi_struct * napi)
(/data00/codes/linux/include/net/gro.h:429)
napi_complete_done(struct napi_struct * n, int work_done)
(/data00/codes/linux/net/core/dev.c:6065)
e1000_clean(struct napi_struct * napi, int budget)
(/data00/codes/linux/drivers/net/ethernet/intel/e1000/e1000_mai
n.c:3811)
__napi_poll(struct napi_struct * n, bool * repoll)
(/data00/codes/linux/net/core/dev.c:6496)
napi_poll(struct list_head * repoll, struct napi_struct * n)
(/data00/codes/linux/net/core/dev.c:6563)
net_rx_action(struct softirq_action * h)
(/data00/codes/linux/net/core/dev.c:6696)
__do_softirq() (/data00/codes/linux/kernel/softirq.c:571)
do_softirq() (/data00/codes/linux/kernel/softirq.c:472)
do_softirq() (/data00/codes/linux/kernel/softirq.c:459)
```

调试kernel收发包流程

用 `curl http://bilibili.com` 测试，在 `__netif_receive_skb_core` 下断点

bt如下

TXT

```
Breakpoint 2, __netif_receive_skb_core
(pskb=pskb@entry=0xffffc90000003da0,
    pfmemalloc=pfmemalloc@entry=false,
ppt_prev=ppt_prev@entry=0xffffc90000003da8)
    at net/core/dev.c:5240
5240    static int __netif_receive_skb_core(struct sk_buff
**pskb, bool pfmemalloc,
(gdb) frame
#0  __netif_receive_skb_core
(pskb=pskb@entry=0xffffc90000003da0,
    pfmemalloc=pfmemalloc@entry=false,
ppt_prev=ppt_prev@entry=0xffffc90000003da8)
    at net/core/dev.c:5240
5240    static int __netif_receive_skb_core(struct sk_buff
**pskb, bool pfmemalloc,
(gdb) bt
#0  __netif_receive_skb_core
(pskb=pskb@entry=0xffffc90000003da0,
    pfmemalloc=pfmemalloc@entry=false,
ppt_prev=ppt_prev@entry=0xffffc90000003da8)
    at net/core/dev.c:5240
#1  0xffffffff81bac595 in __netif_receive_skb_list_core (
    head=head@entry=0xffff888003ddccb8,
pfmemalloc=pfmemalloc@entry=false)
    at net/core/dev.c:5528
#2  0xffffffff81bacd3b in __netif_receive_skb_list
(head=0xffff888003ddccb8)
    at net/core/dev.c:5595
#3  netif_receive_skb_list_internal
(head=head@entry=0xffff888003ddccb8)
    at net/core/dev.c:5686
#4  0xffffffff81bad4be in gro_normal_list
(napi=0xffff888003ddcbb0)
    at ./include/net/gro.h:439
#5  gro_normal_list (napi=0xffff888003ddcbb0) at
./include/net/gro.h:435
#6  napi_complete_done (n=n@entry=0xffff888003ddcbb0,
work_done=<optimized out>)
    at net/core/dev.c:6026
```

```
#7  0xffffffff819b8863 in e1000_clean (napi=0xffff888003ddcbb0,
budget=64)
    at drivers/net/ethernet/intel/e1000/e1000_main.c:3811
#8  0xffffffff81bad627 in __napi_poll
(n=n@entry=0xffff888003ddcbb0,
    repoll=repoll@entry=0xffffc90000003f47) at
net/core/dev.c:6460
#9  0xffffffff81badcb2 in napi_poll (repoll=0xffffc90000003f58,
n=0xffff888003ddcbb0)
    at net/core/dev.c:6527
#10 net_rx_action (h=<optimized out>) at net/core/dev.c:6660
#11 0xffffffff81f0a5a0 in __do_softirq () at
kernel/softirq.c:553
#12 0xffffffff81091a8e in do_softirq () at kernel/softirq.c:454
#13 do_softirq () at kernel/softirq.c:441
```

inet_init 添加 ipv4 的 packet handler

`receive_skb*` 有list和非list版本，list可以做GRO合并，根据条件将多个skb合并，减少重复处理次数

调用顺序

> netif_receive_skb_list
> __netif_receive_skb_list_core
> __netif_receive_skb_core
> deliver_skb

> 回调packet_type的handler
> 5.

路由选择

__fib_lookup

fib_lookup

struct rtable

代表一条路由规则，路由结束绑定到skb#_skb_refdst

- struct dst_entry dst;
  - 下面详细介绍。
- _u16 rt_type
  - 本路由类型

字段	值	ip route	含义
RTN_UNICAST	1	unicast	默认值，如果skb#_skb_refdst是此值，数据需要被转发
RTN_LOCAL	2	local	本机路由
RNT_BROADCAST	3	广播	需要转发
RTN_MULTICAST	5	多播	多播
RNT_UNREACHABLE	7	unreachable	丢弃，返回ICMP network unreachable

- __u8 rt_uses_gateway
  - bool，路由的下一跳是网关(ip route 返回类似 `via 10.0.0.1` 的格式)，那么 `rt_gw4`包含网关IP地址。
- u8 rt_gw_family
  - 如果rt_uses_gateway是0，那rt_gw_family是0。如果网关地址是IPV4，=AF_INET。IPV6, =AF_INET6
- union {__be32 rt_gw4; struct in6_addr rt_gw6;}
  - 如果是网关，根据IP类型使用 `rt_gw4` 或 `rt_gw6` 字段

struct dst_entry

- struct net_device *dev
  - 发送数据的网络设备，数据包最终从此设备发送
- struct xfrm_state *xfrm
  - 和IPsec 相关，一般是NULL
- int (_input)(struct sk_buff_skb)
  - 根据路由结果，input是不同值。决定数据包接下来如果处理。dest ip本机则继续向上传递。不是本机的ip则转发

可选值	备注
dst_discard	默认值
ip_local_deliver	目的地址是本机，或者广播数据包
ip_forward	单播，但不是本机，需要转发
ip_error	没有找到匹配路由，*unreachable*，数据包丢弃，返回ICMP host unreachable

可选值	备注
lwtunnel_input	Kconfig - net/Kconfig - Linux source code (v5.14.7) - Bootlin

- int (_output)(struct net_net, struct sock _sk, struct sk_buff_skb);
  - 根据路由结果output指向不同函数。决定数据包如何发送

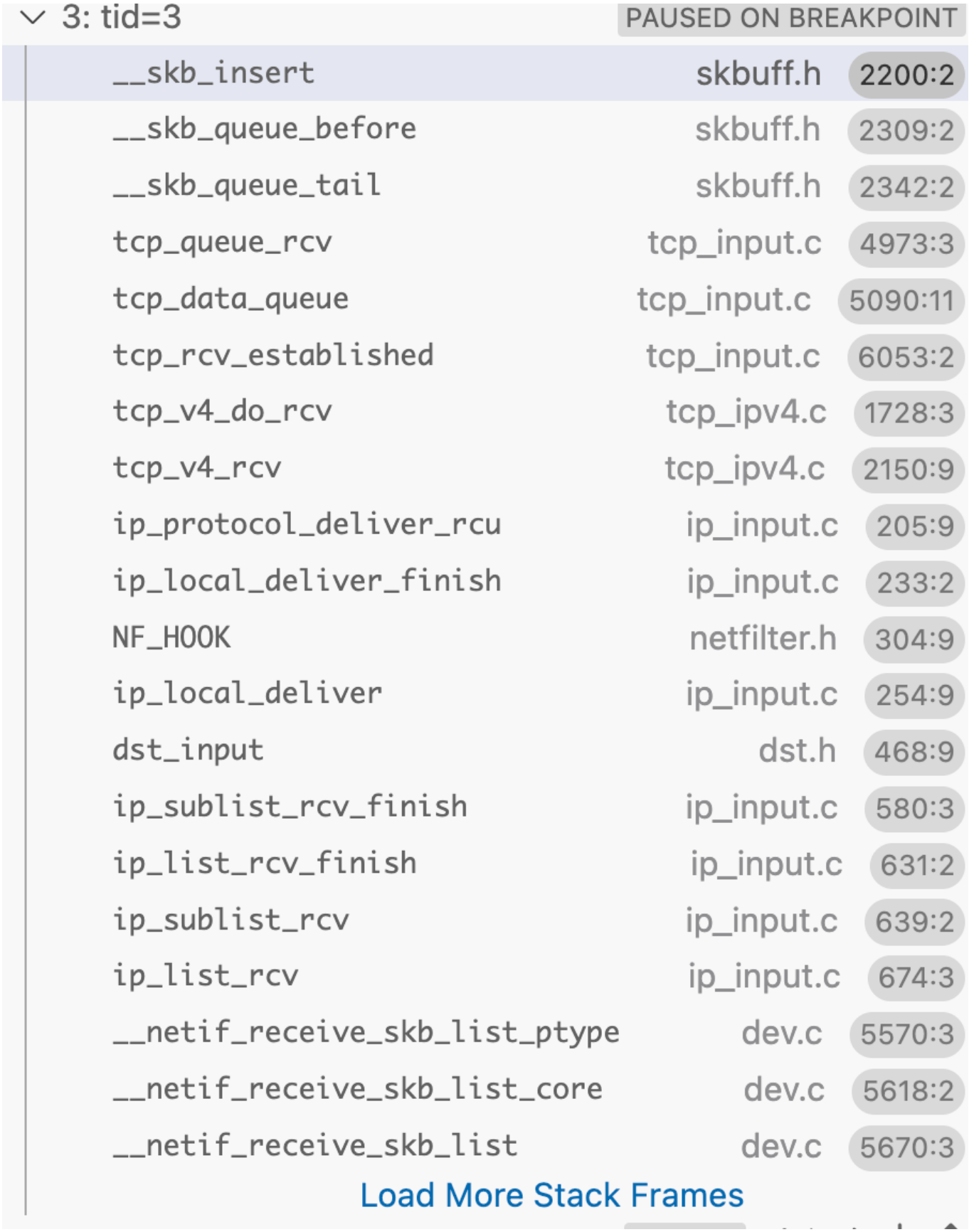
可选值	备注
dst_discard_out()	默认值
ip_output	本机生成，需要发送的单播包
ip_rt_bug()	bug?
xfrm4_output	要转发的数据包
ip_mc_output	本机生成，需发送的多播（multicast）包

skb 到 sock

UDP sock send to skb

tcp sock send

tcp sock receive from skb


3: tid=3
PAUSED ON BREAKPOINT
__skb_insert skbuff.h 2200:2
__skb_queue_before skbuff.h 2309:2
__skb_queue_tail skbuff.h 2342:2
tcp_queue_rcv tcp_input.c 4973:3
tcp_data_queue tcp_input.c 5090:11
tcp_rcv_established tcp_input.c 6053:2
tcp_v4_do_rcv tcp_ipv4.c 1728:3
tcp_v4_rcv tcp_ipv4.c 2150:9
ip_protocol_deliver_rcu ip_input.c 205:9
ip_local_deliver_finish ip_input.c 233:2
NF_HOOK netfilter.h 304:9
ip_local_deliver ip_input.c 254:9
dst_input dst.h 468:9
ip_sublist_rcv_finish ip_input.c 580:3
ip_list_rcv_finish ip_input.c 631:2
ip_sublist_rcv ip_input.c 639:2
ip_list_rcv ip_input.c 674:3
__netif_receive_skb_list_ptype dev.c 5570:3
__netif_receive_skb_list_core dev.c 5618:2
__netif_receive_skb_list dev.c 5670:3
Load More Stack Frames

参考

> Routing Decisions in the Linux Kernel - Part 1: Lookup and packet flow [Thermalcircle.de]
> networking:kernel_flow [Wiki]