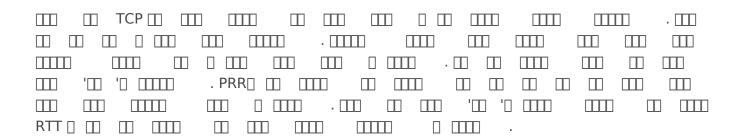
FreeBSD? RACK??? TCP??

by Randall Stewart and Michael TÜxen

: Tuxen.pdf П 2017
☐ FreeBSD☐ TCP ☐ ☐ ☐ ☐ ☐ TCP ☐ ПП . ПП TCP III . 🔲 П П ПП $\Pi\Pi$. SYN-Cookies 🔲 , 📖 IP \square ☐ TCP П П ТСРПП ПП SYN-Cache ∏∏ ПП ПП TCP III TCP [, □ TCP □ TCP IIII П ПППП TCP RACK ____ tcp_do_segment() ____ \square ПП . 🔲 . RACK∏ ∏∏ ППП ПП , 2021∏ RFC 8985∏ m . [] TCP [[[]] RACK IIII . TCP RACK [] ПППП ☐ (SACK) ☐ . ППП ППП ПП . TCP RACK [m ППП ППП \Box RACK Ⅲ RFC 8985□ □□ ППП ППП ПП ПП ПП ПП П . 🗆 🗆 🗆 TCP RACK ?? ?? ?? FreeBSD CURRENT FreeBSD 14.0 RACK Ⅲ . 🔲 ППП FreeBSD | TTT Π ПП FreeBSD 14.0 □ □ □ П ПП ППП option TCPHPTS makeoptions WITH EXTRA TCP STACKS=1 . [] [] TCP [] □□□ (HPTS)□ □□□ ПППП ПП ППП . TCP ППП $\cdot \square \square \square$ TCP RACK IIII □ □ (tcp_rack.ko) □ □ □ ППП RACK IIII tcp_rack_load="YES" /boot/loader.conf Ⅲ Ⅲ Ⅲ ПП ПП ПППП

FreeBSD CURRENT[]] TCP RACK[] HPTS[] [] [] []]
<pre>tcphpts_load="YES" tcp_rack_load="YES"</pre>
☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
option TCPHPTS option TCP_RACK
TCP
sysctl net.inet.tcp.functions_available
☐ FreeBSD ☐ TCP RACK ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
□ □□□ □□□ FreeBSD 14.1 □□□□ TCP RACK □□□ □□□□ □□□ FreeBSD CURRENT □ □□□□□ .
TCP RACK
sysctl-variable net.inet.tcp.functions_default[] socket(2) [] [] [] [] [] [] [] TCP [] TCP RACK [] [] [] [] .
<pre>sysctl net.inet.tcp.functions_default=rack</pre>
/etc/sysctl.conf [] [] [] [] [] [] TCP RACK [] [] TCP [] .
net.inet.tcp.functions_default=rack
listener TCP TCP TCP Sysctl-variable net.inet.tcp.functions_inherit_listen_socket_stack 0 TCP
□ □ □ □ □ □ □ tcpsso(8) □ □ □ □ TCP □ TCP □ □ □ □ □ □ □ ·

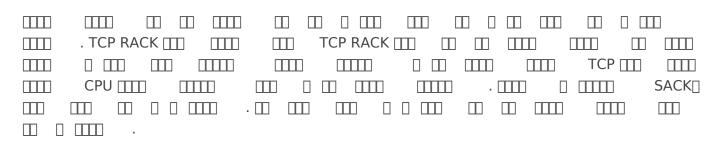
```
______, TCP_FUNCTION_BLK_____
                           IPPROTO_TCP □ □ □
      ☐ ☐ TCP ☐ TCP RACK ☐ ☐
tcp_function_set ____ . ___ __ __ , ___ ___ ___
                    \mathsf{m}
                         :
 struct tcp_function_set tfs;
 strncpy(tfs.function_set_name, "rack", TCP_FUNCTION_NAME_LEN_MAX);
 tfs.pcbcnt = 0;
 setsockopt(fd, IPPROTO_TCP, TCP_FUNCTION_BLK, &tfs, sizeof(tfs));
TCP RACK []
           TCP RACK ??? ??
TCP RACK []
              RACK/TLP
Recent Acknowledgement (RACK)□ Tail Loss Probe (TLP)□ TCP RACK □□
                                 ППП
    . RACK 📗 🔛
             RFC 5681□ □□
                 TCP III
ППП
            SACK III III IIII
          4 | | | | | |
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        TCP IIII
                       . RACK 🛮 🖽 🔠
                                  SACK | | | | | | |
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                    □ RTT□ □ □ □ ), □ RACK □ □ □
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     . .
                  ПП
                     TLP  
        ☐ TLP ☐☐
                        . TLP IIII
                              TCP RACK []
                   . 🛮 TLP 🖽
ППП
                              ☐ ) TLP☐ SACK☐ ☐☐☐
(\Box\Box
                        ПП
  TCP RACK [ ]
                         RACK TLP III
          ПП
               ППП
                   Proportional Rate Reduction (PRR)
     ☐ (PRR)☐ TCP RACK ☐ ☐ ☐ ☐ ☐ ☐ ☐
                             , RFC 6937□ □□□
                                          П
```



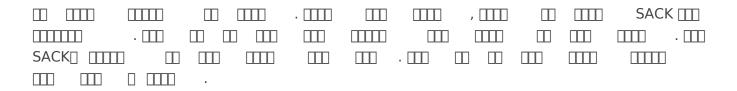
RACK Rapid Recovery (RRR)

```
RACK Rapid Recovery(RRR)
          □□□□ . □□ □□□ □□□ TCP RACK □□□
        SACK[] [[[[]]]
      ПП
 ППП
   RACK IIII
         . RACK IIII
                   ☐ ☐ 1ms☐ ☐ ), TCP RACK ☐ ☐
            . .
            □ □ □ PRR□ □□□
☐ PRR ☐☐☐
         . ___ RRR__ _ _ _ _
\cdot \Box \Box \Box
       , [
     □ RRR □ □
```

SACK Attack Detection



```
option TCP SAD DETECTION
```



Burst Mitigation

TCP RACK IIII \Box . ППП . . ПП ПП

Support for TCP Blackbox Logging (BBLog)

TCP RACK □□□ \cdot \square \square \square

Large Receive Offload (LRO) Integration for Burst Mitigation

____ TCP _____ **TCP** ПП ПППП CPU IIII . 🔲 , TCP _____ \prod \Box ПП ПП П TCP IIII ПП CPU IIII TCP RACK IIII LRO III \square , \square . TCP III . 🛮 🔲 LRO III . TCP RACK [] . TCP RACK [IP Ⅲ CPU IIII . .

A Host of Alternate Features

sysctl-variables TCP RACK П ПППП TCP RACK [, 🔲 . 🔲 TCP RACK □ □ □ 150□ sysctl-variables□ □□□ . . ☐ TCP RACK ☐ ☐

????? TCP RACK ??? ????? ??

TCP RACK [] [] [] [] [] [] [] [] [] [
TCP RACK
?? ? ?? TCP RACK FreeBSD
TCP RACK
(tuexen@freebsd.org)

Revision #2