Zero-Copy BPF Buffers

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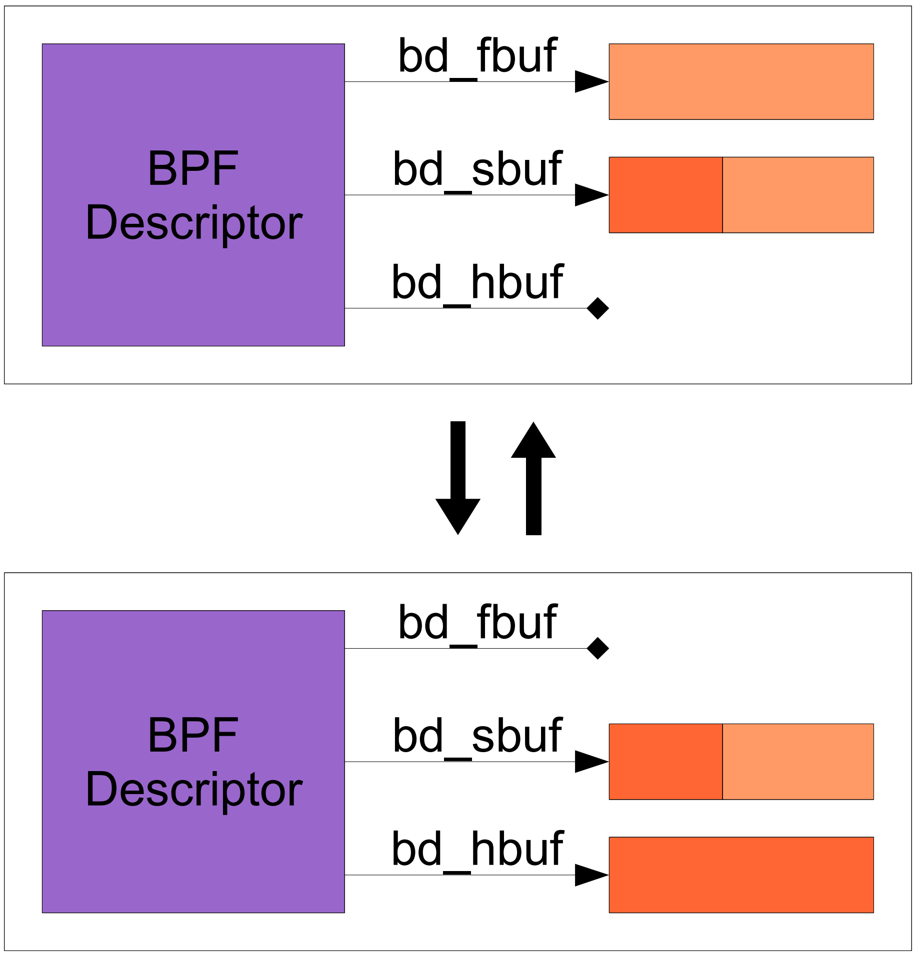
BPF: Berkeley Packet Filter

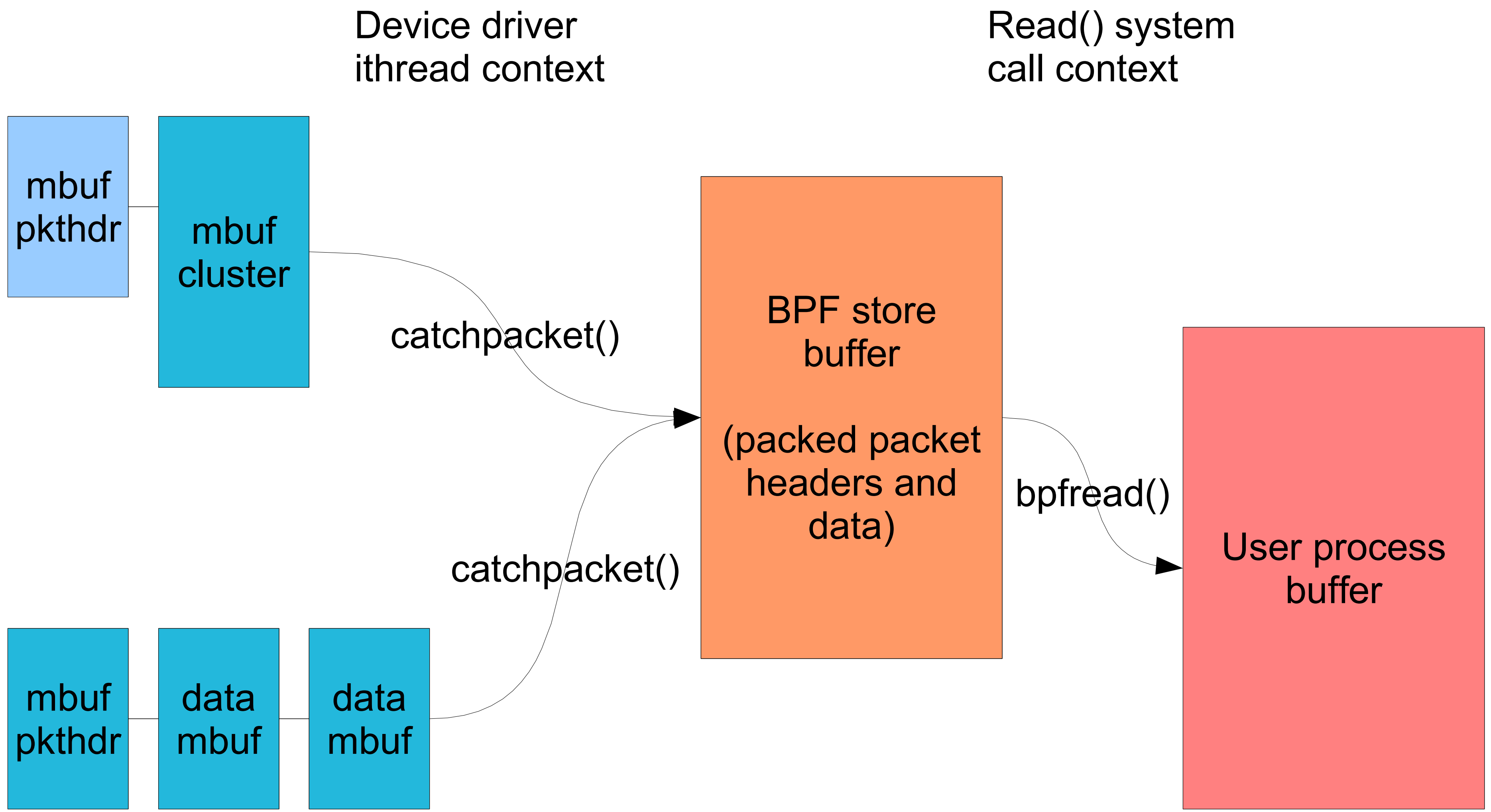
- BPF provides user process interface for link layer receive and transmit
  - Open special device /dev/bpfX
  - Program in-kernel packet filter
  - Select interface, optionally set promiscuous mode
  - Loop on read() to read buffers of a fixed size
- Problem: minimum of two copies per packet
  - mbufs -> kernel buffer -> user memory
  - A significant performance overhead

BPF Buffer Model



- Two rotating buffers per descriptor
- Rotate between free, store, and hold buffers
- Hold buffer returns to free slot after bpfread() drains to user space

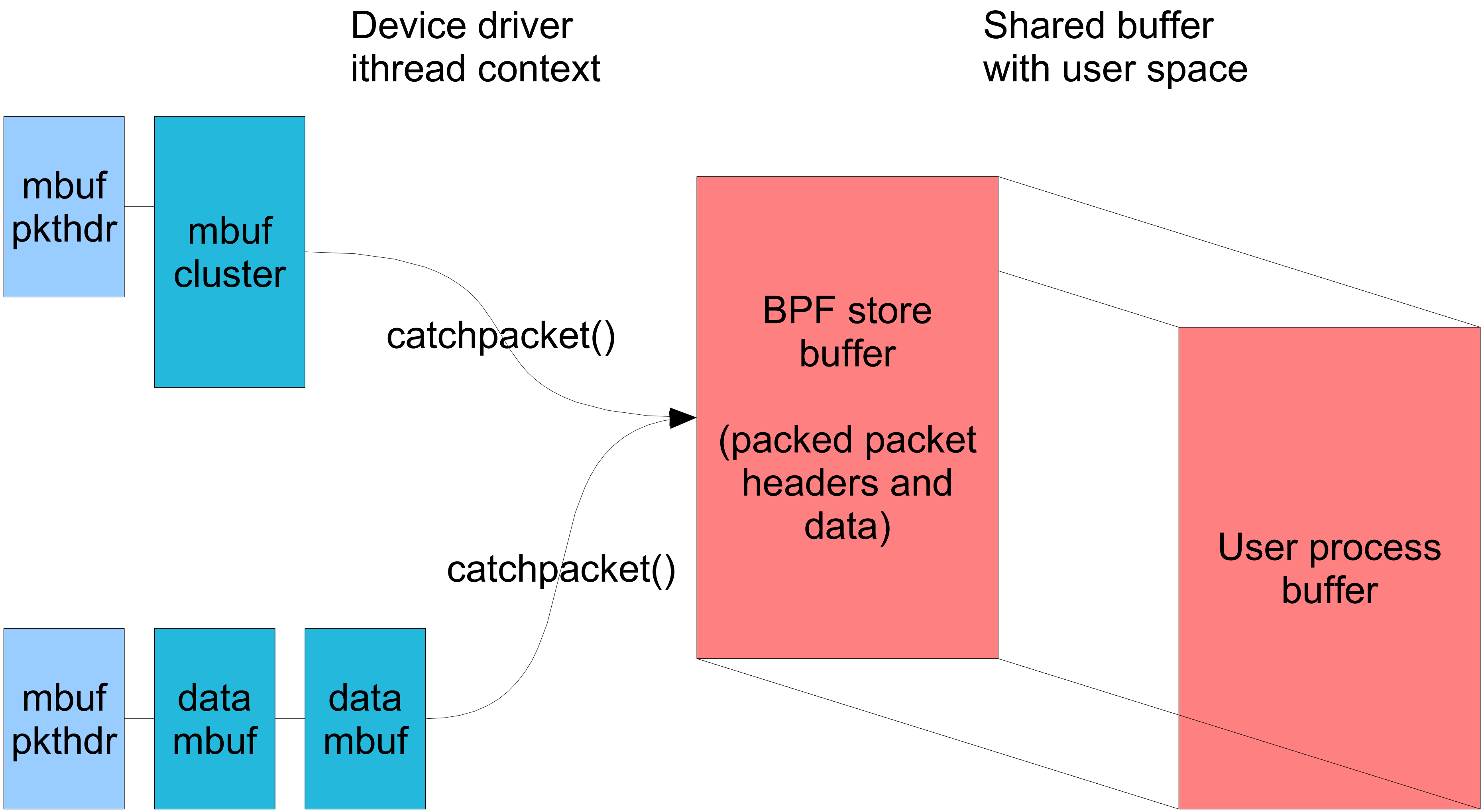
BPF Data Copies (Currently)



BPF Buffer Problem

- Problem: too many data copies
- Solution: shared memory buffer between user process and BPF
- Eliminates copy to user space, not in-kernel
  - Strictly, now “one-copy” BPF, zero-copy buffers
  - In-kernel copy prevents leaking of kernel memory
  - Allows independence between BPF devices (different filters, snaplens, etc)

Shared Memory BPF Store Buffer



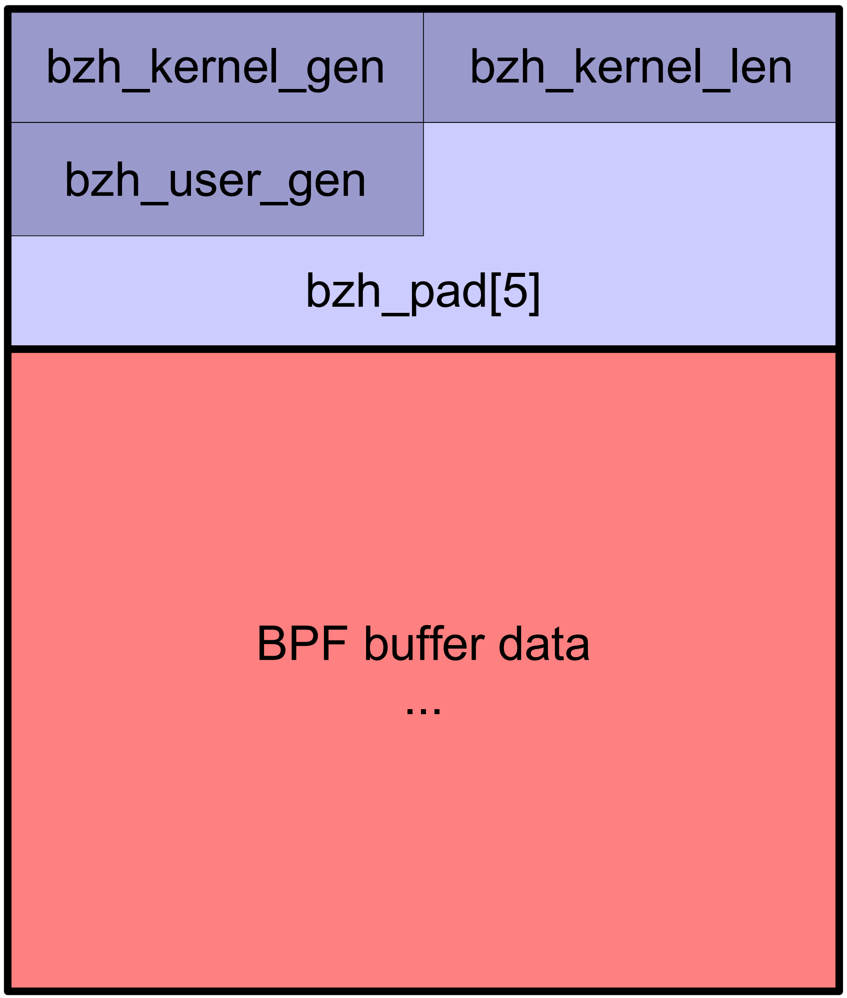
Shared Memory BPF Buffers

- User process
  - Selects non-default mode BPF_BUFFER_ZBUF
  - Allocates two page-aligned, identically sized buffers
  - Set buffer size and locations with BIOCSETZBUF
- Kernel
  - Maps user buffers into kernel address space
  - Pins into physical memory
  - Uses buffers instead of kernel memory for bd_{fbuf, sbuf, hbuf}

Shared Memory BPF Buffers (cont)

- User process may use syscalls and ioctls:
  - Poll(), etc, to monitor for complete buffers
  - Query next held buffer using BIOCGETZNEXT
  - Force rotation using BIOCROTZBUF to time out partially filled buffer
  - Return held buffer to free slot using BIOCACKZBUF
- Or query and acknowledge buffers using a shared memory header at the front of the buffer
  - Forced rotation still requires BIOCROTZBUF

Memory-Mapped BPF Buffer Layout



- Memory buffer prefixed with shared memory header
  - Used for system call free synchronization between kernel and user app
- Remainder of buffer uses standard BPF buffer layout

BPF Implementation Changes

- Abstract buffer access
  - Default is BPF_BUFMODE_BUFFER uses kernel memory and full data copies
  - Optional BPF_BUFMODE_ZBUF uses shared user/kernel memory buffers with reduced copies
- New ioctls
  - Configure, manage shared memory buffers
- Libpcap
  - Modified to speak both models

Current Status

- Not much testing or evaluation yet, but works
- Faster in some benchmarks, slower in others
  - Wins for simple buffer traversal benchmark...
  - ... but not for complex memory scanning benchmark
    - Could be experimental error (not well-tested yet)
    - Could be increased overhead of scatter-gather copy?
    - Cache misses also moved around, may need work
    - Or might just not be faster not to copy
- Need to do a full hwpmc analysis, comprehensive benchmarking

Where to get it?

- Perforce: //depot/projects/zcopybpf/...
- Coordinate with Christian Peron (csjp@) and Robert Watson (rwatson@)
- Sponsored by Seccuris Inc

Direct-to-disk BPF

- 10gbps packet capture
  - 10gbps to user process memory should be OK
  - 10gbps to disk entirely a different matter
- New buffer mode would cause direct commit to file and/or disk
- Currently exploring design options
  - Lack of high-end storage hardwares key limitation
  - Notice that 1.25GBps is a lot faster than a disk