New sendfile(2)

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Netflix

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Miserable life w/o sendfile(2)

```
while ((cnt = read(filefd, buf, (u_int)blksize))
    write(netfd, buf, cnt) == cnt)
        byte_count += cnt;
```

send_data() в src/libexec/ftpd/ftpd.c,
FreeBSD 1.0, 1993

sendfile(2) introduced

int
sendfile(int fd, int s, off_t offset, size_t nbytes, ..);

- 1997: HP-UX 11.00
- 1998: FreeBSD 3.0 and Linux 2.2

sendfile(2) in FreeBSD

- First implementation - mapping userland cycle to the kernel:
  - read(filefd) → VOP_READ(vnode)
  - write(netfd) → sosend(socket)
  - blksize → PAGE_SIZE

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  - 2004: SF_NODISKIO flag
  - 2006: inner cycle, working on sbspace() bytes
  - 2013: sending a shared memory descriptor data

Problem #1: blocking on I/O

Algorithm of a modern HTTP-server:

1. Take yet another descriptor from kevent(2)
2. Do write(2)/read(2)/sendfile(2) on it
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Bottleneck: any syscall time.

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- Separate I/O contexts: processes, threads
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  - Apache
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- SF_NODISKIO + aio_read(2)
  - nginx
  - Varnish

More attempts . . .

- aio_mlock(2) instead of aio_read(2)
- aio_sendfile(2) ???

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- Not easy to prevent it doing that!

waht if VOP_GETPAGES()?

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- Pros:
  - sendfile() already works on pages
  - implementations for vnode and shmem converge
  - control over VM is now easier task

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  - sendfile() already works on pages
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- Cons
  - Losing readahead heuristics ☹
  - But no one used them! ☺

VOP_GETPAGES_ASYNC()

int
*VOP_GETPAGES(struct vnode *vp, vm_page_t *ma, int count, int reqpage);*

1. Initialize buf(9)
2. buf->b_iodone = bdone;
3. bstrategy(buf);
4. bwait(buf); /* sleeps until I/O completes */
5. return;

VOP_GETPAGES_ASYNC()

int
*VOP_GETPAGES_ASYNC(struct vnode *vp,*
*vm_page_t *ma, int count, int reqpage,*
*vop_getpages_iodone_t *iodone, void *arg);*

1. Initialize buf(9)
2. buf->b_iodone = vnode_pager_async_iodone;
3. bstrategy(buf);
4. return;

vnode_pager_async_iodone calls iodone() .

naive non-blocking sendfile(2)

In kern_sendfile():

1. nios++;
2. VOP_GETPAGES_ASYNC(sendfile_iodone);

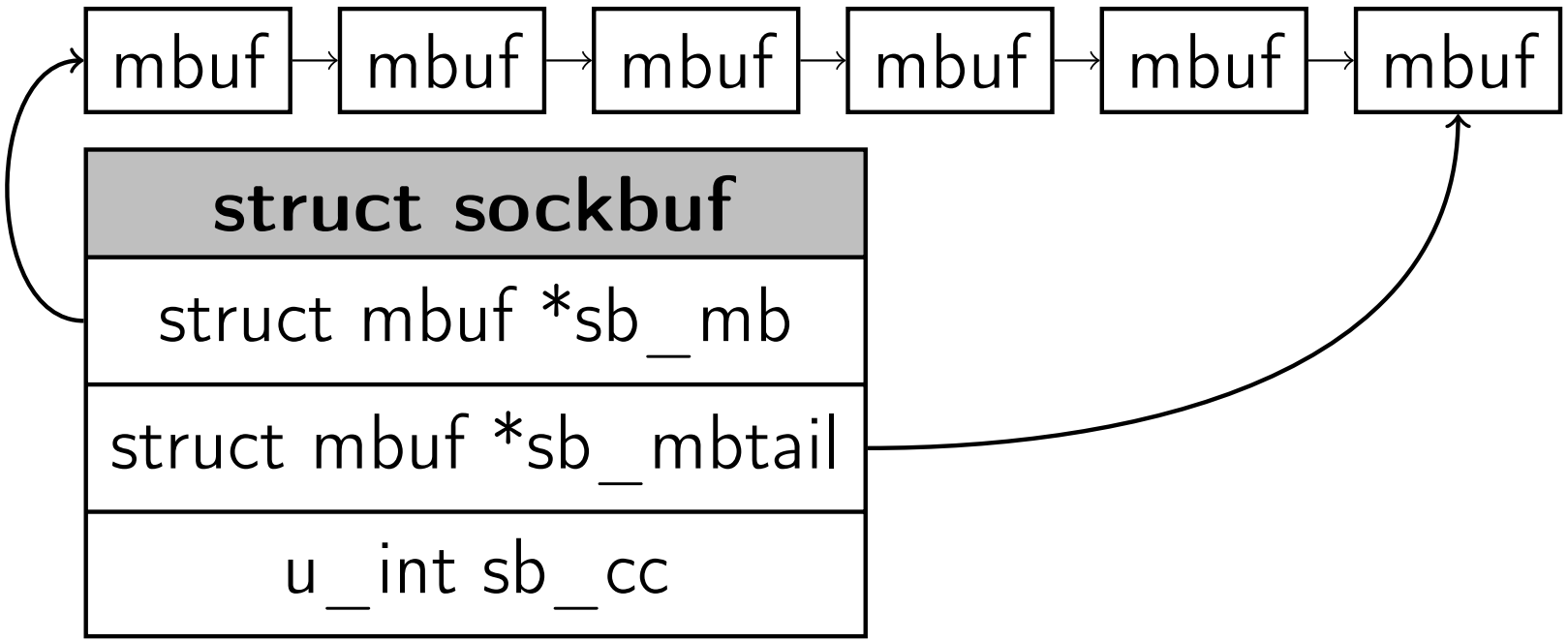
In sendfile_iodone():

1. nios--;
2. if (nios) return;
3. sosend();

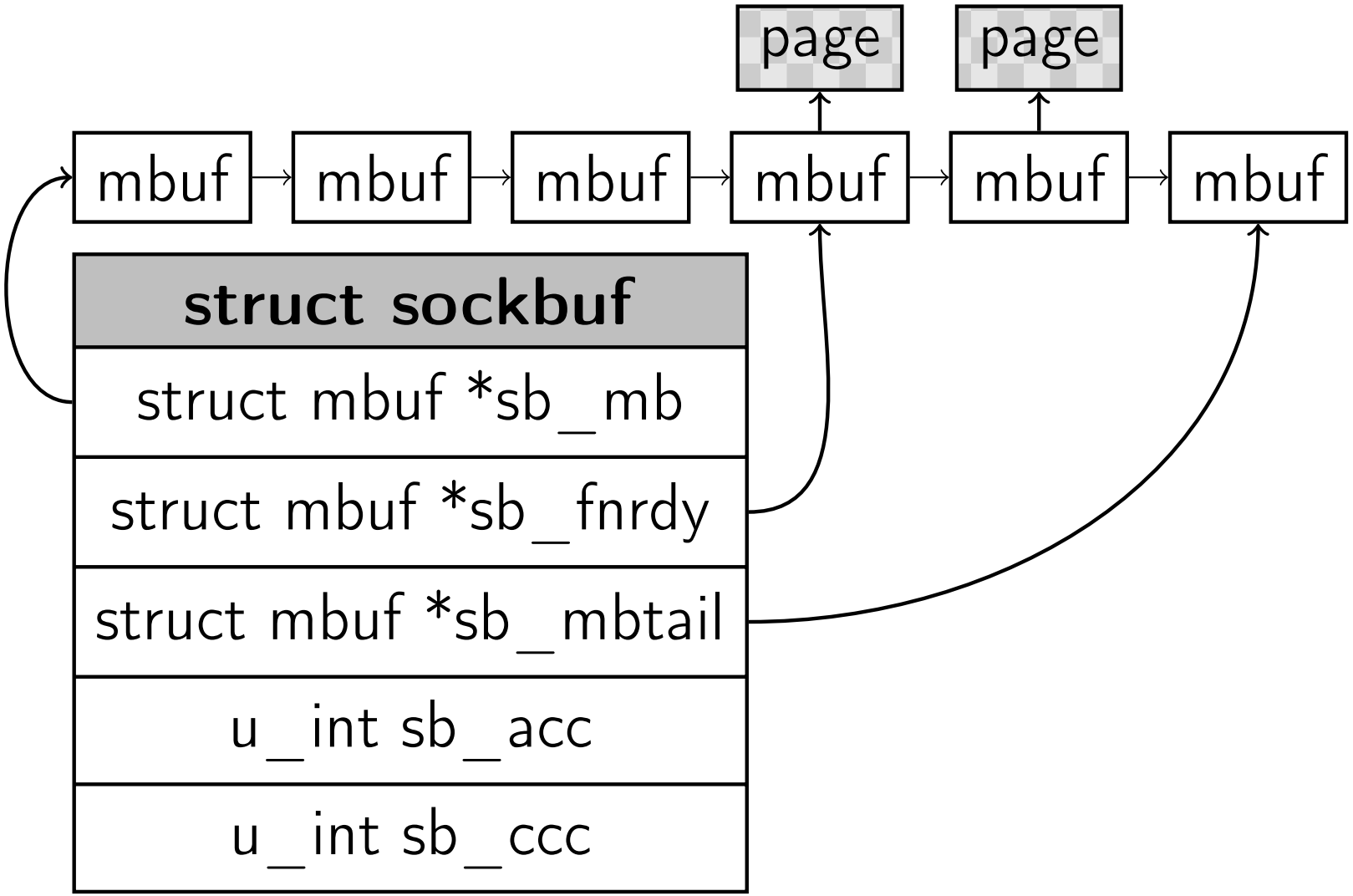
the problem of naive implementation

```
sendfile(filefd, sockfd, ..);
write(sockfd, ..);
```

socket buffer



socket buffer with "not ready" data



non-blocking sendfile(2)

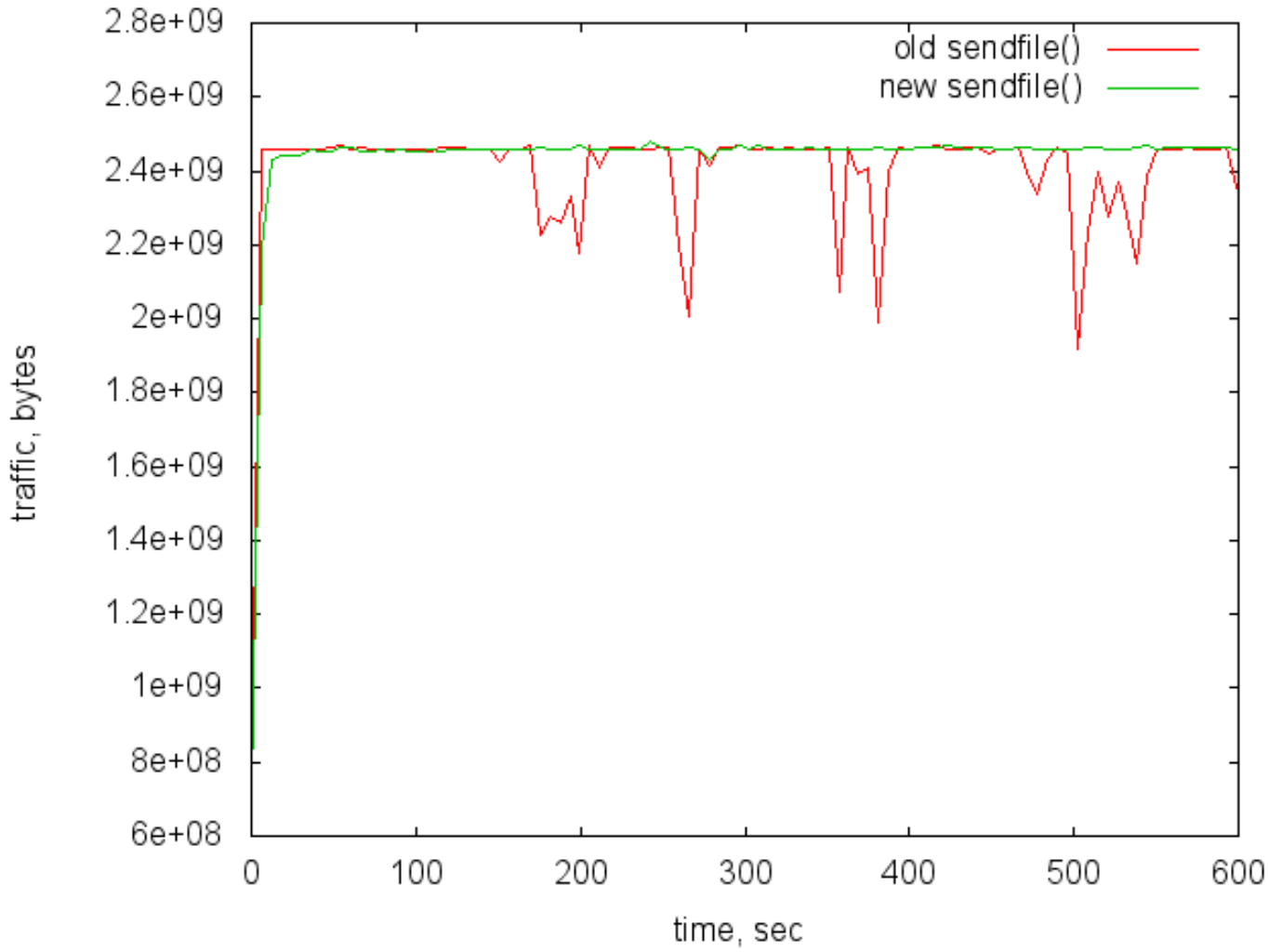
In kern_sendfile():

1. nios++;
2. VOP_GETPAGES_ASYNC(sendfile_iodone);
3. sosend(NOT_READY);

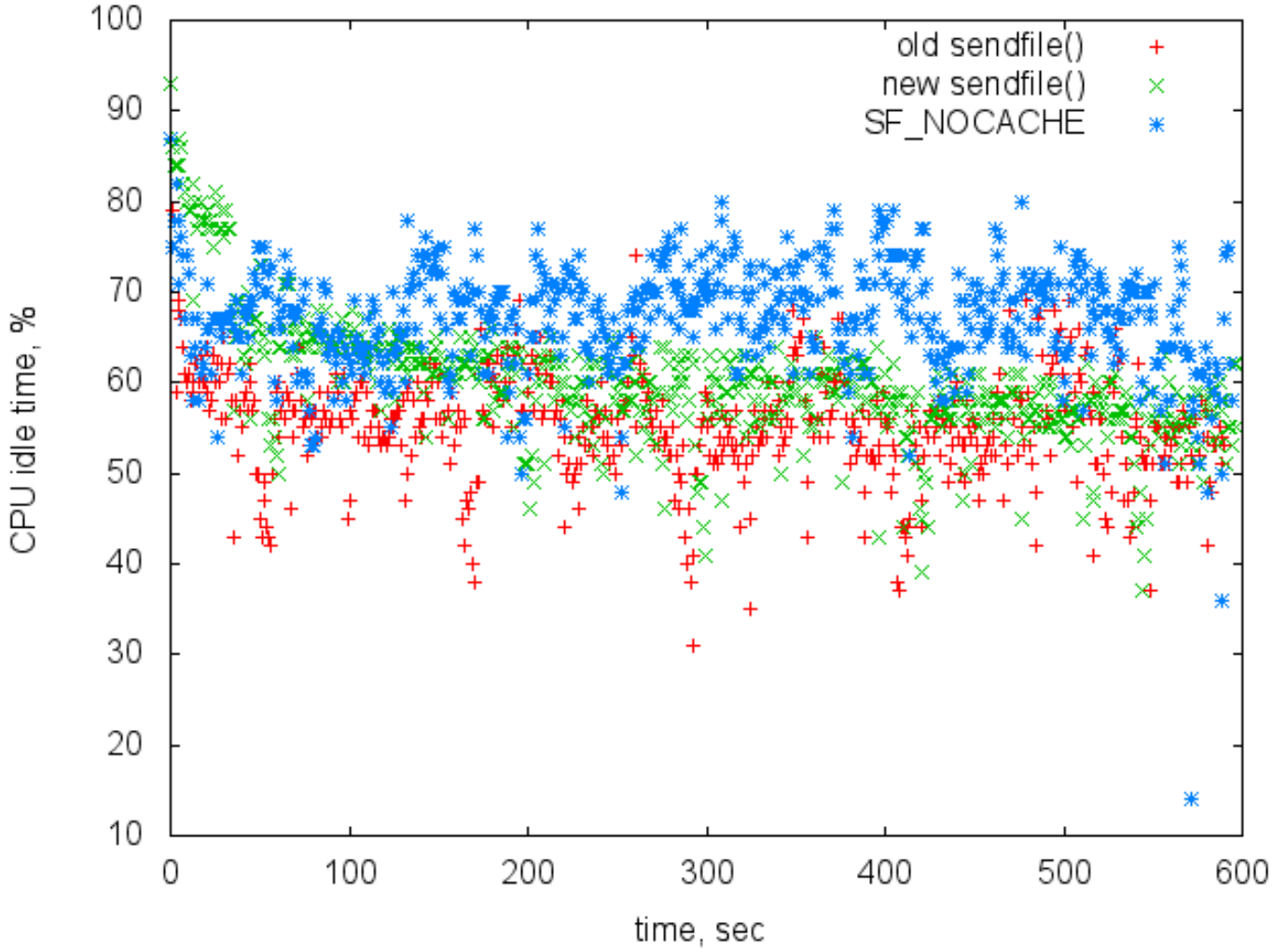
In sendfile_iodone():

1. nios--;
2. if (nios) return;
3. soready();

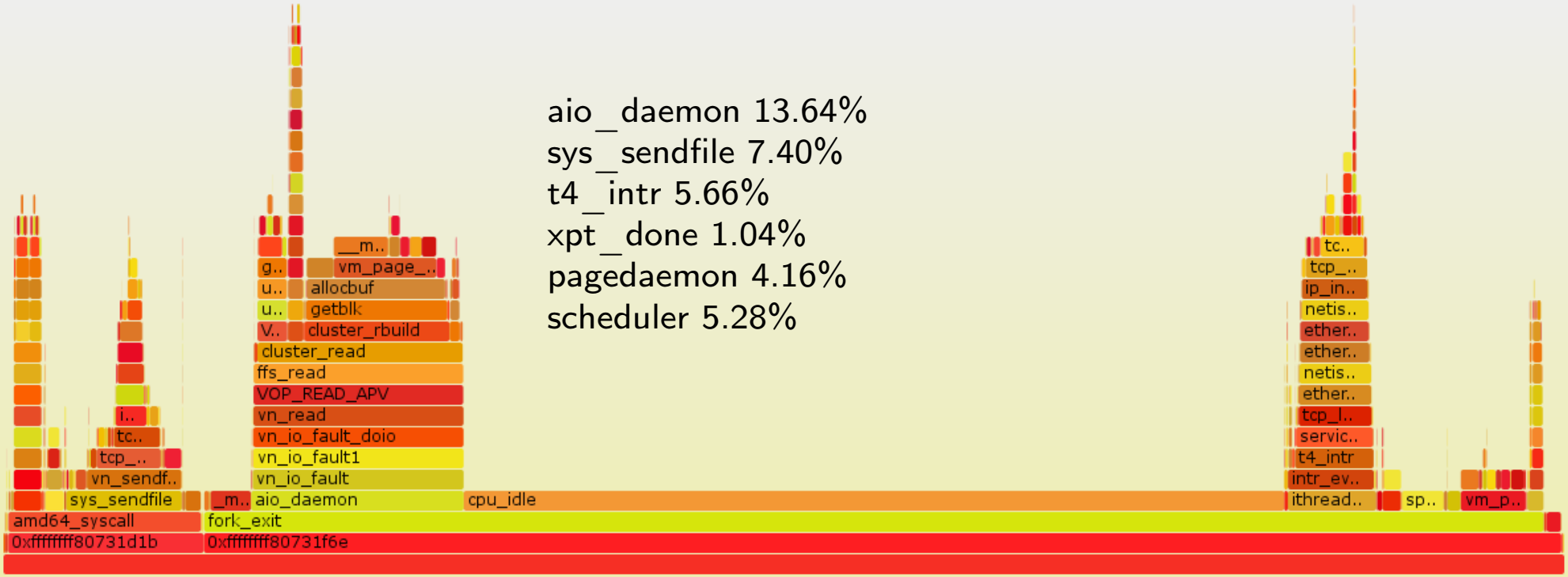
traffic


old sendfile()
new sendfile()
traffic, bytes
time, sec
2.8e+09
2.6e+09
2.4e+09
2.2e+09
2e+09
1.8e+09
1.6e+09
1.4e+09
1.2e+09
1e+09
8e+08
6e+08
0
100
200
300
400
500
600

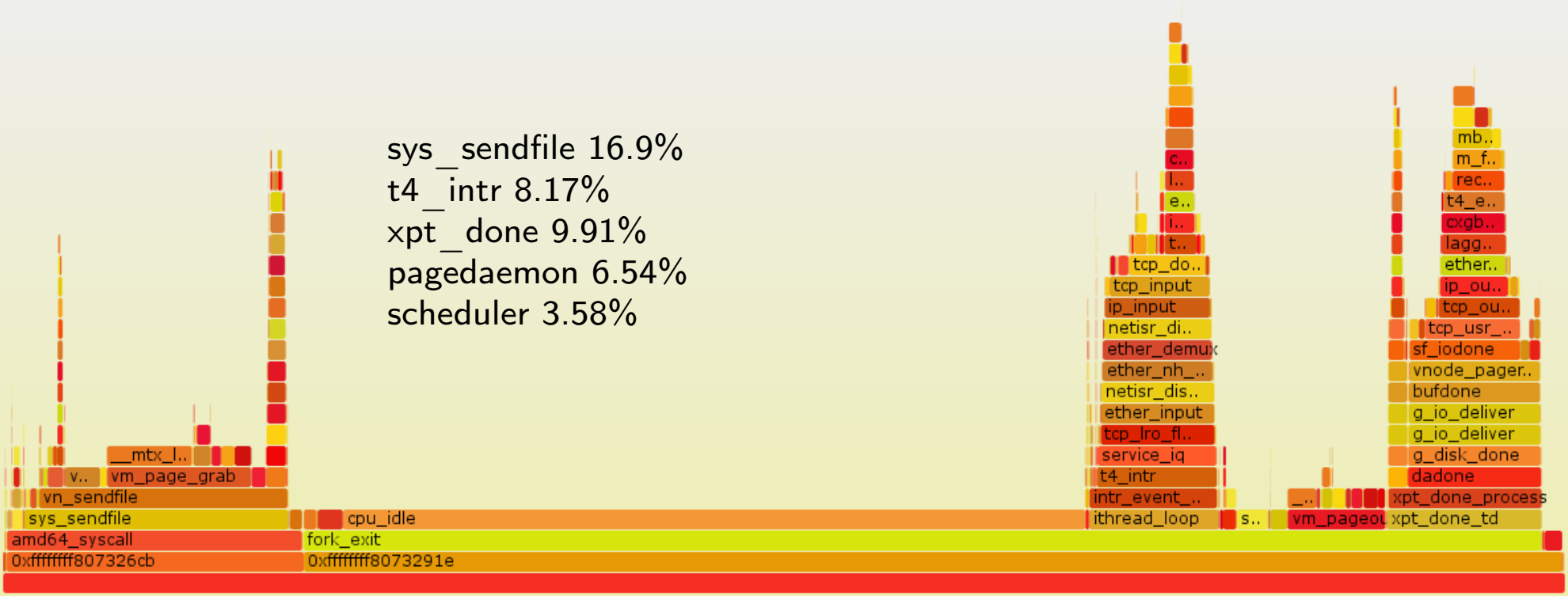
CPU idle


old sendfile()
new sendfile()
SF_NOCACHE
CPU idle time, %
time, sec
100
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600

profiling sendfile(2) in head



profiling new sendfile(2)



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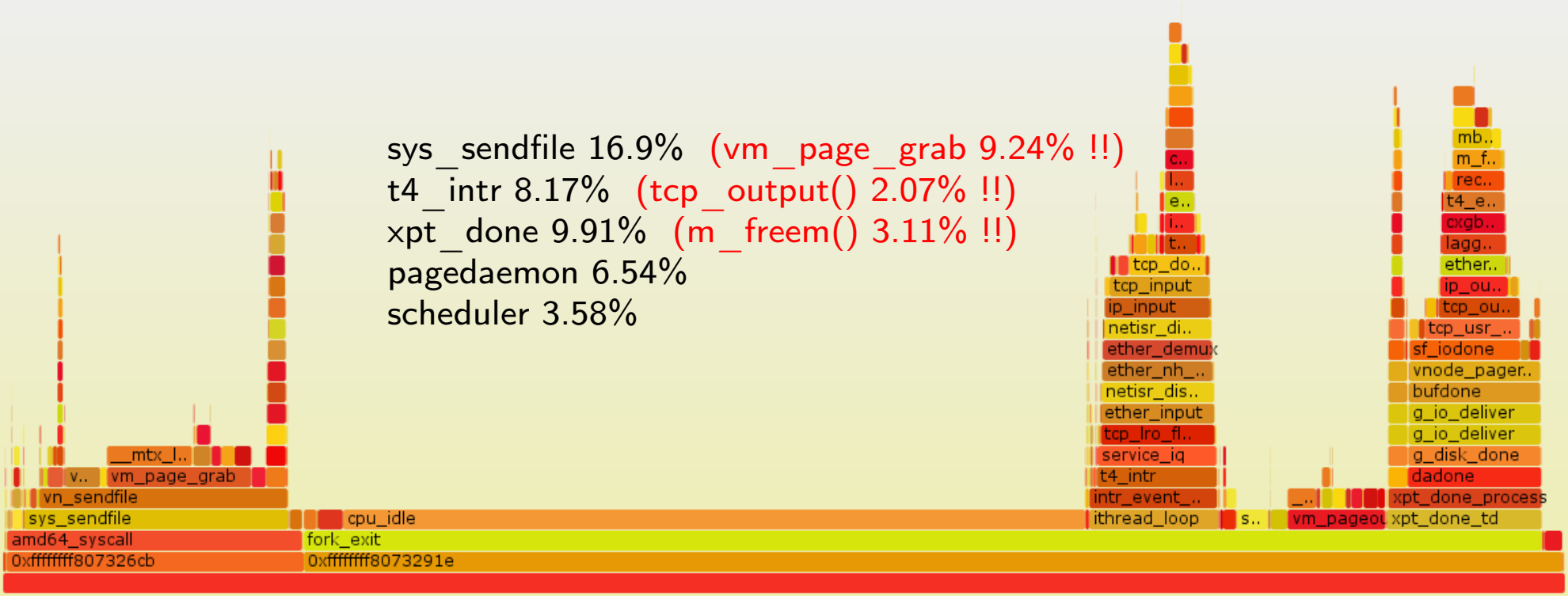

what did change?

- New code always sends full socket buffer
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  - Which hurts VM, mbuf allocator, and unexpectedly TCP stack

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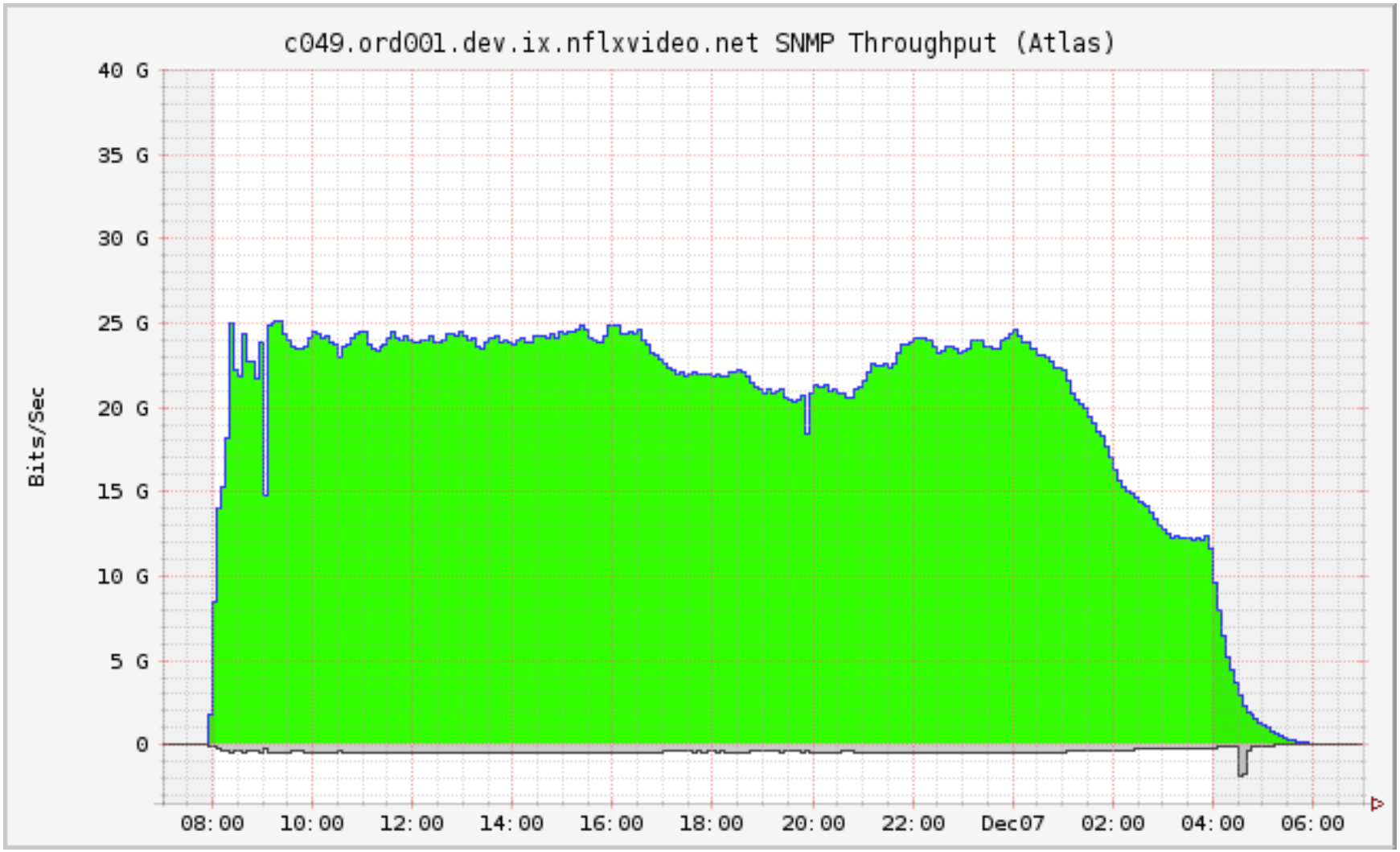
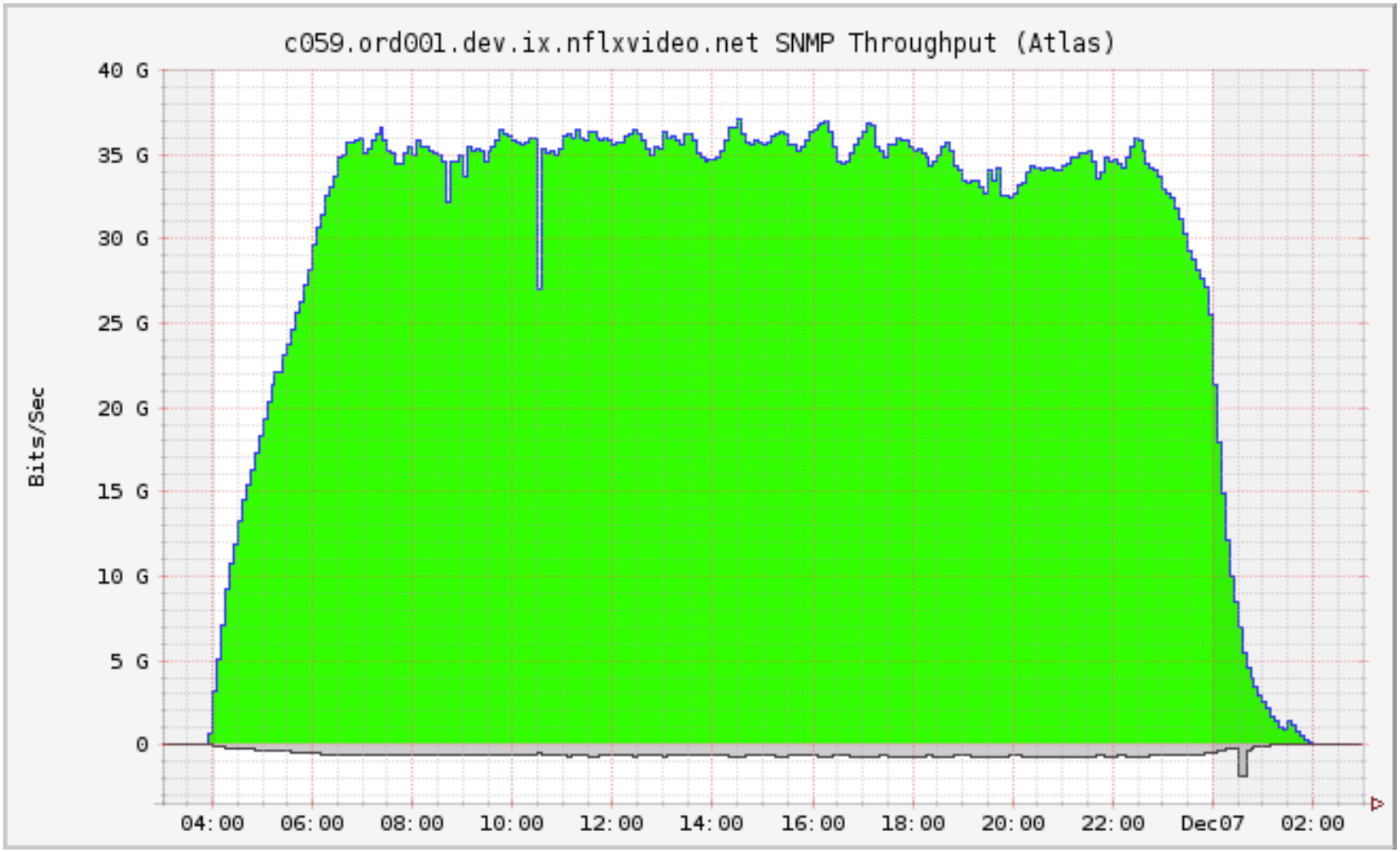
- New code always sends full socket buffer
  - Which is good for TCP (as protocol)
  - Which hurts VM, mbuf allocator, and unexpectedly TCP stack
- Will fix that!

old sendfile(2) @ Netflix



new sendfile(2) @ Netflix



TODO list

Problems:

- VM & I/O overcommit
- ZFS
- SCTP

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Future plans:

- sendfile(2) doing TLS

Questions?