CRFS

Coherent Remote File System

An introduction to a work in progress.

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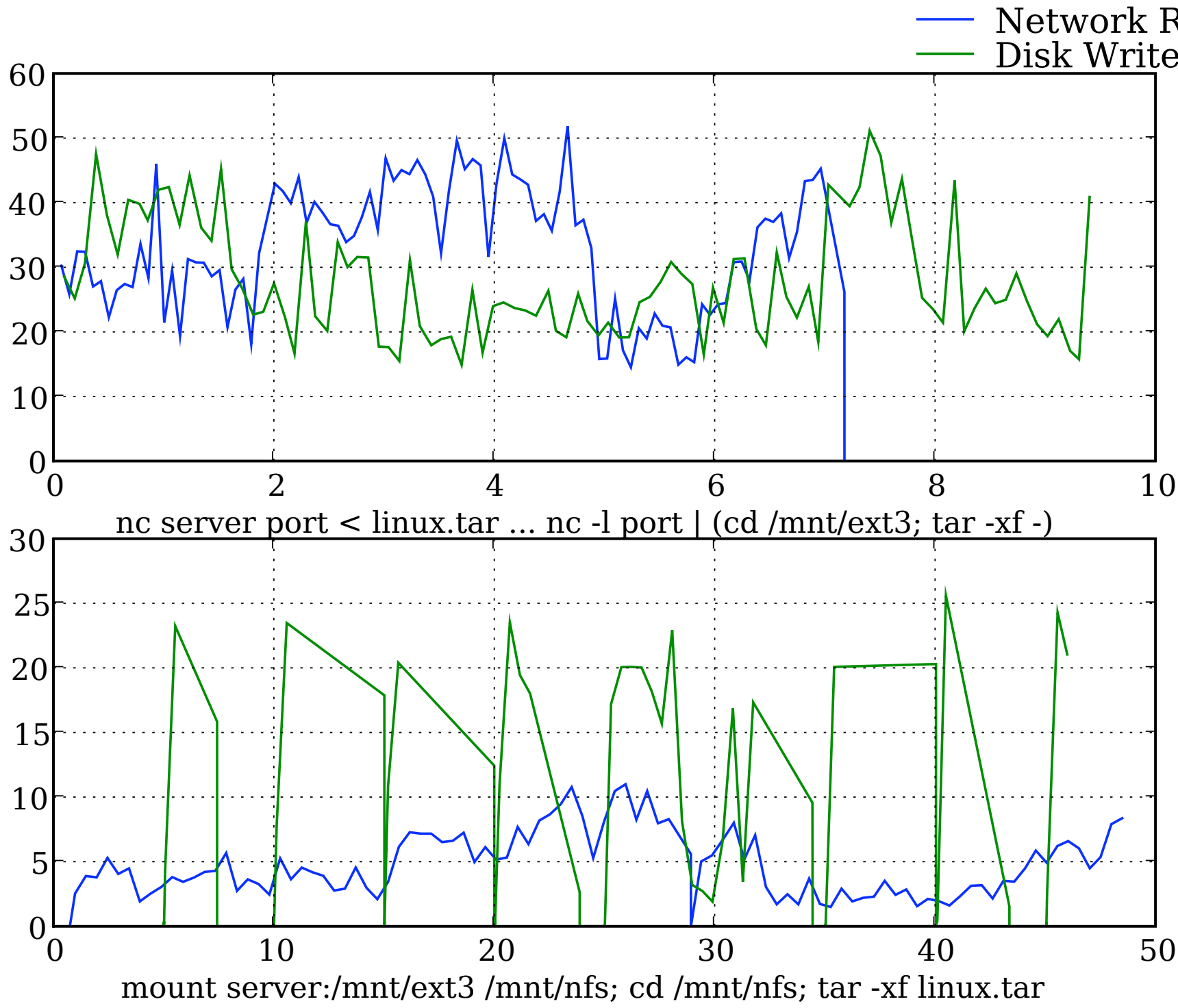
Outline

- Motivation
- System overview
- BTRFS disk format
- CRFS metadata wire format
- Some performance results
- Coherency overview


Network RX
Disk Write
60
50
40
30
20
10
0
0
2
4
6
8
10
nc server port < linux.tar ... nc -l port | (cd /mnt/ext3; tar -xf -)
30
25
20
15
10
5
0
0
10
20
30
40
50
mount server:/mnt/ext3 /mnt/nfs; cd /mnt/nfs; tar -xf linux.tar

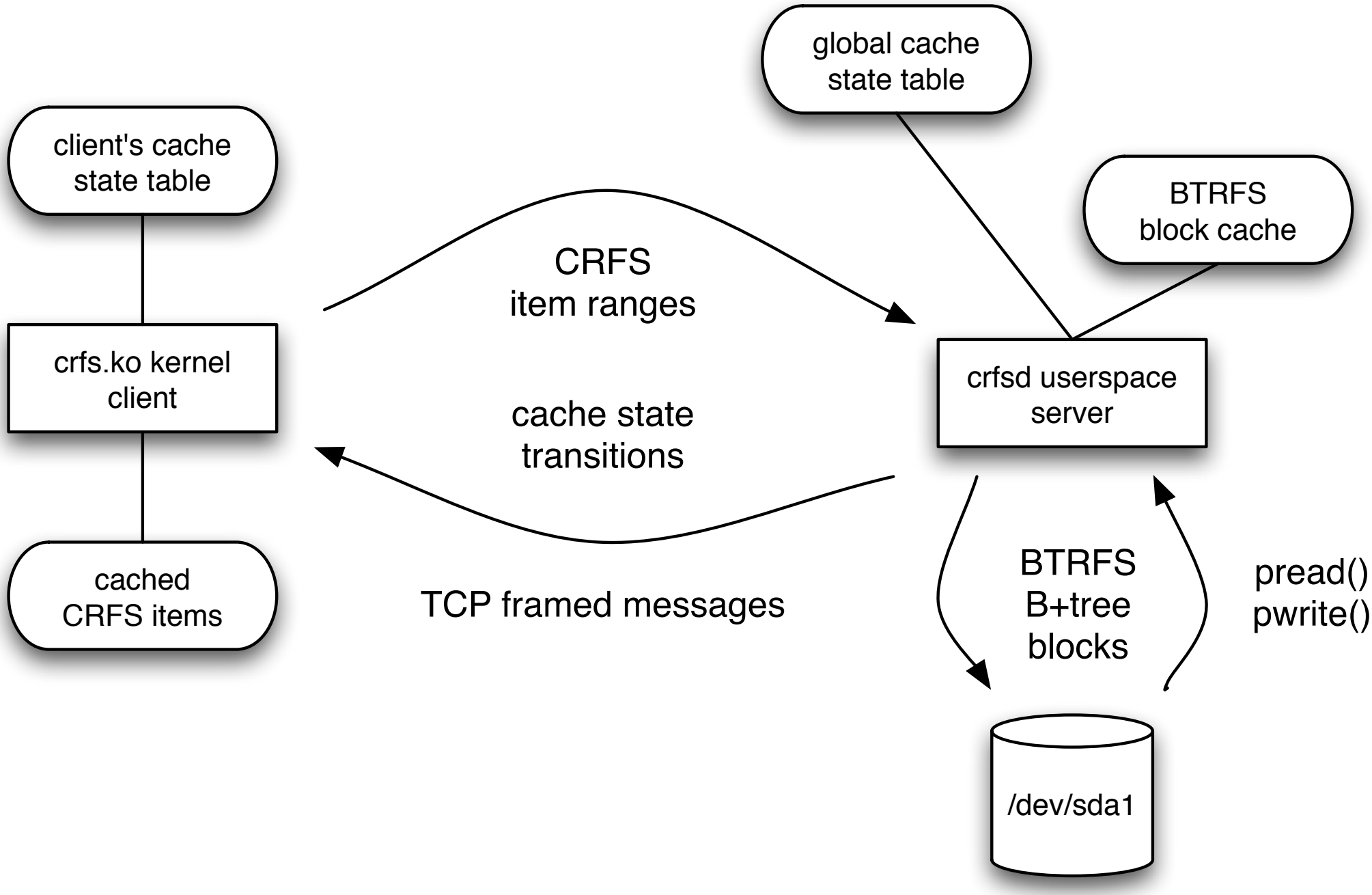
UNIX (“POSIX”,“local”)

```
mkdir("dir", 0700)              = 0
open("dir", O_RDONLY)           = 3
creat("dir/file", 0600)         = 4
unlink("dir/file")              = 0
rmdir("dir")                    = 0

getdents(3, 0x7fffe4f404f0, 4096) = -1 ENOENT
```

Linux NFS (“bonghits”)

```
mkdir("dir", 0700)              = 0
open("dir", O_RDONLY)           = 3
creat("dir/file", 0600)         = 4
unlink("dir/file")              = 0
rmdir("dir")                    = -1 ENOTEMPTY

getdents(3,
  {{d_ino=21825147, d_off=1, d_reclen=24, d_name=".."}
  {d_ino=21825151, d_off=2, d_reclen=24, d_name="."}
  {d_ino=21825156, d_off=3, d_reclen=48,
        d_name=".nfs00000000014d06840000003c"}}, 4096) = 96
```

CRFS system overview

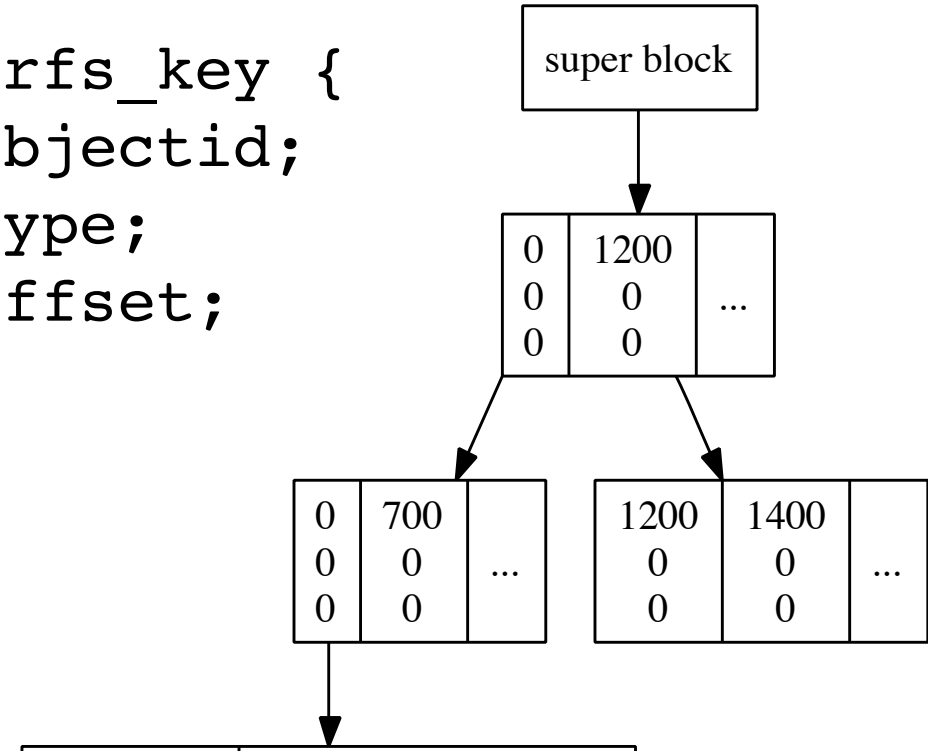


stuff we get from BTRFS

(stuff you can't get from POSIX alone)

- idempotent compound atomic writes
- client-to-drive checksums of file data
- access to unlinked files
- snapshots
- never overwrite referenced data
- walking new data via transaction numbers

```
struct btrfs_key {
     u64 objectid;
     u8  type;
     u64 offset;
};
```



...	...
300 'inode' 0	.st_ino = 300 .st_mode = S_ISDIR
300 'dirent' TEA('hw')	.de_ino = 301 .de_namelen = 2 .de_name[] = 'hw'
301 'inode' 0	.st_ino = 301 .st_mode = S_ISREG .st_size = 11
301 'file data' 0	'hello world'

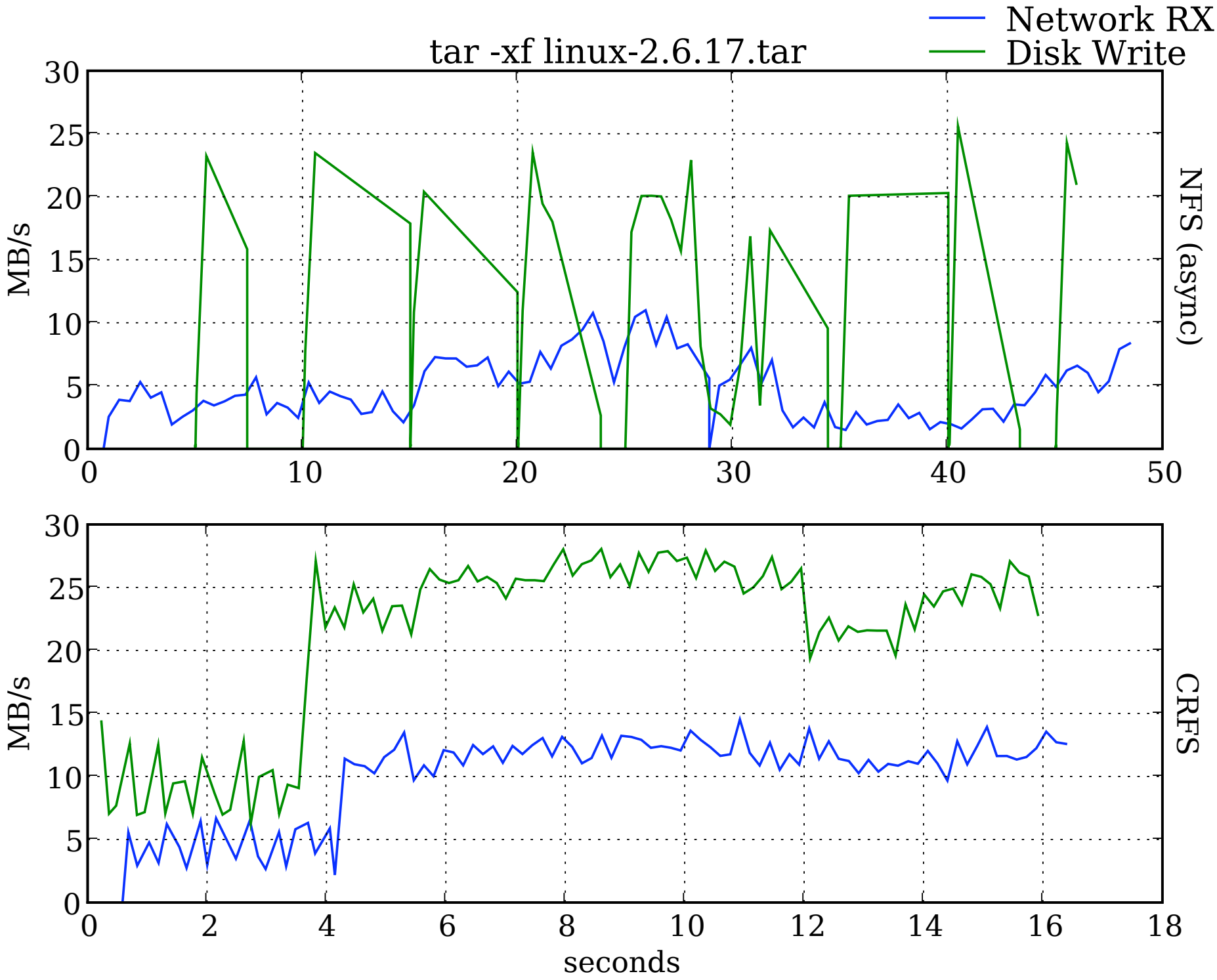
```
struct crfs_msg_item_query {
        struct crfs_key         key;
        struct crfs_key         min;
        struct crfs_key         max;
        le32                    bytes;
};

struct crfs_item {
        struct crfs_key         key;
        le32                    offset;
        le16                    size;
};

struct crfs_item_range {
        struct crfs_key         min;
        struct crfs_key         max;
        le16                    nr_items;
        struct crfs_item        items[0];
};
```

empty FS mount query

```
header id 1 info 0 bytes 64 type 2 [CRFS_MSG_ITEM_QUERY]
  query key (~0.~0.~0) min (0.0.0) max (~0.~0.~0) bytes 4028

header id 1 info 0 bytes 356 type 3 [CRFS_MSG_ITEM_RANGE]
  range nr 4 min (5.1.0) max (~0.~0.~0)
    off 104 size 104 key (5.i.0)
      ino sz 42 nlink 1 uid 0 gid 0 mode DIR|0755
    off 208 size 26 key (5.d.0x1)
      dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (5.0.0)
    off 234 size 27 key (5.d.0x2)
      dent len 2 type 2 [CRFS_FT_DIR] name '..' loc (5.0.0)
    off 261 size 53 key (5.D.5)
      dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (5.0.0)
```

mkdir transaction

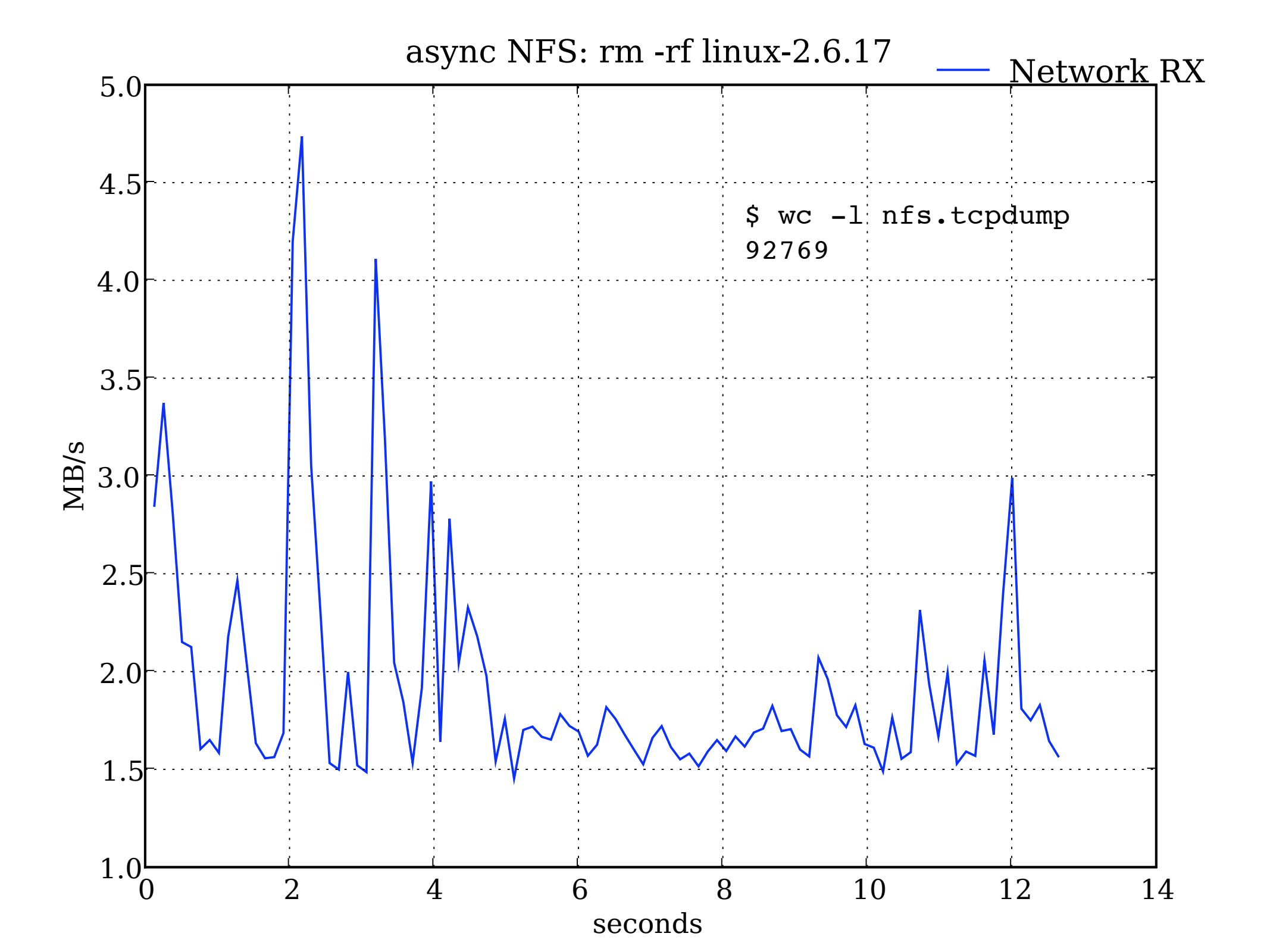
```
header id 2 info 0 bytes 4075 type 6 [CRFS_MSG_TRANS_FRAG]
  frag nr 0 last 0 type 0    range nr 11 min (5.1.0) max (~0.~0.~0)
      off 3818 size 104 key (5.i.0)
        ino sz 42 nlink 2 uid 0 gid 0 mode DIR|0755
      off 3922 size 26 key (5.d.0x1)
        dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (5.0.0)
      off 3948 size 27 key (5.d.0x2)
        dent len 2 type 2 [CRFS_FT_DIR] name '..' loc (5.0.0)
      off 3681 size 33 key (5.d.0x9371c7261dac5bea)
        dent len 8 type 2 [CRFS_FT_DIR] name 'some-dir' loc (6.i.0)
      off 3975 size 53 key (5.D.5)
        dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (5.0.0)
      off 3648 size 33 key (5.D.6)
        dent len 8 type 2 [CRFS_FT_DIR] name 'some-dir' loc (6.i.0)
      off 3714 size 104 key (6.i.0)
        ino sz 2 nlink 2 uid 0 gid 0 mode DIR|0755
      off 3622 size 26 key (6.d.0x1)
        dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (6.i.0)
      off 3569 size 27 key (6.d.0x2)
        dent len 2 type 2 [CRFS_FT_DIR] name '..' loc (5.i.0)
      off 3542 size 27 key (6.D.5)
        dent len 2 type 2 [CRFS_FT_DIR] name '..' loc (5.i.0)
      off 3596 size 26 key (6.D.6)
        dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (6.i.0)

header id 2 info 0 bytes 0 type 1 [CRFS_MSG_FINAL_REPLY]
```


tar -xf linux-2.6.17.tar
Network RX
Disk Write
MB/s
NFS (async)
0
5
10
15
20
25
30
0
10
20
30
40
50
MB/s
CRFS
0
2
4
6
8
10
12
14
16
18
seconds

contrived optimal deletion

(but not as unlikely as you might suspect!)

```
mount -t crfs server /mnt/crfs && cd /mnt/crfs
tar -zxf /somewhere/mercurial-0.9.1.tar.gz && sync
crfsdctl snoop > /tmp/output-down-there &
rm -rf mercurial-0.9.1/ && sync


header id 14 info 0 bytes 4075 type 6 [CRFS_MSG_TRANS_FRAG]
  frag nr 0 last 0 type 0    range nr 4 min (5.1.0) max (~0.~0.~0)
      off 3924 size 104 key (5.i.0)
        ino sz 42 nlink 1 uid 0 gid 0 mode DIR|0755
      off 3898 size 26 key (5.d.0x1)
        dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (5.0.0)
      off 3871 size 27 key (5.d.0x2)
        dent len 2 type 2 [CRFS_FT_DIR] name '..' loc (5.0.0)
      off 3778 size 53 key (5.D.5)
        dent len 1 type 2 [CRFS_FT_DIR] name '.' loc (5.0.0)

header id 14 info 0 bytes 0 type 1 [CRFS_MSG_FINAL_REPLY]
```

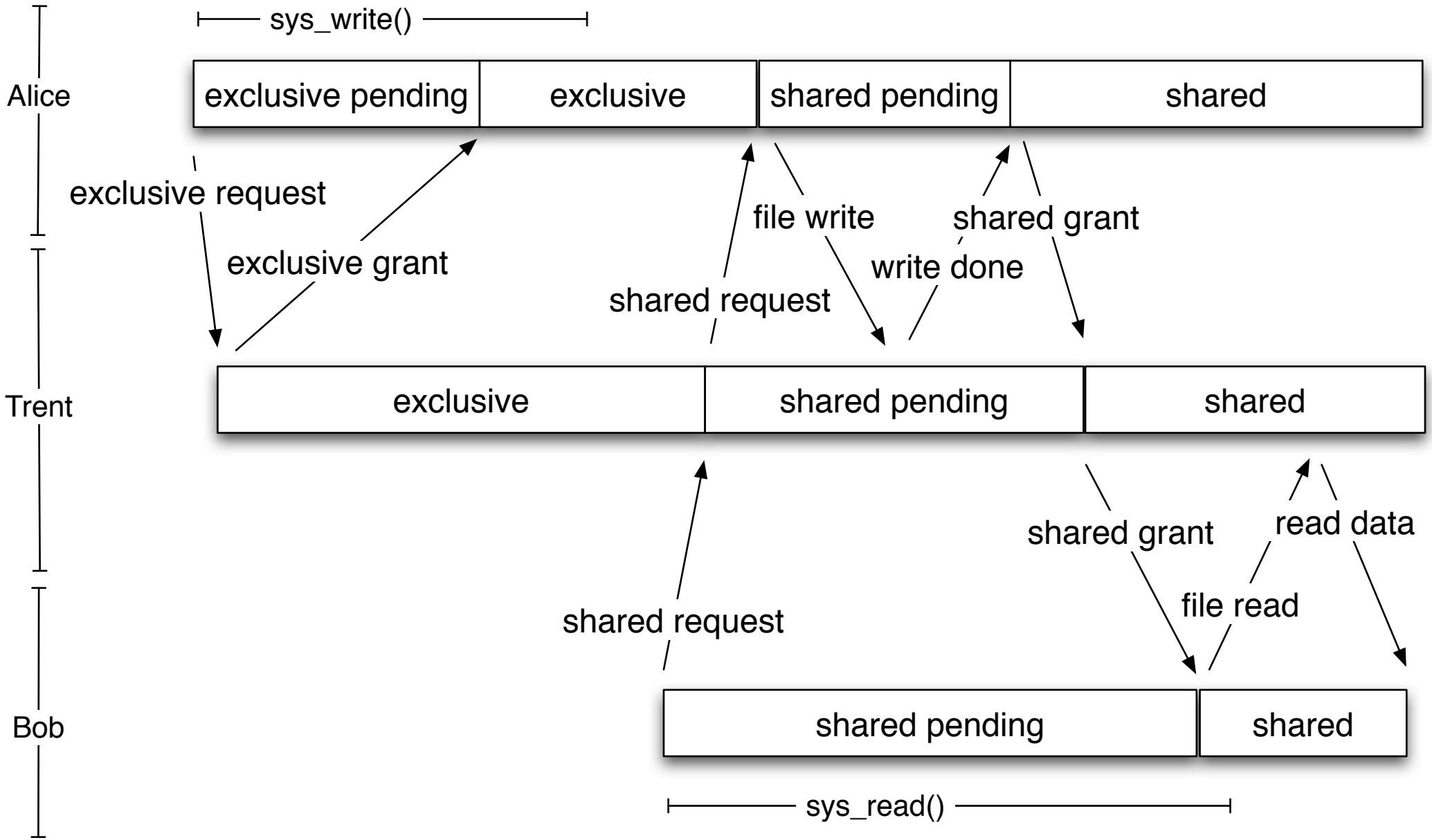

async NFS: rm -rf linux-2.6.17
Network RX
$ wc -l nfs.tcpdump
92769
MB/s
seconds
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
2
4
6
8
10
12
14

rm -rf linux-2.6.17 in 86 packets

```
1201046467.364473 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364486 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364491 IP (length 1208) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364511 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.364714 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364723 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364728 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364778 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.364793 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.364964 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364971 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364976 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364981 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.364985 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365055 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365083 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365097 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365114 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365274 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365281 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365286 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365290 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365294 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365366 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365381 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365388 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365398 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365402 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365406 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365450 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365541 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365548 IP (length 1245) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365553 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365557 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365620 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365636 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365643 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365648 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365652 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365657 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365662 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365666 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365671 IP (length 1014) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365676 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365756 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365767 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365790 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365812 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365816 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365820 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365823 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.365864 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.365875 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.366105 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366112 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366117 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366121 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366132 IP (length 169) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366136 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366141 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366145 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366150 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366155 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366159 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366165 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366169 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366174 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366178 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366184 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366310 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366331 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.366341 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.366355 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046467.366889 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366897 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.366901 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046467.367137 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046468.045693 IP (length 73) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046468.045960 IP (length 52) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046468.164605 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046468.164614 IP (length 1500) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046468.164619 IP (length 1252) sdp2.pdx.zabbo.net.48004 > sdp1.58398
1201046468.164631 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046468.203114 IP (length 52) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046468.233309 IP (length 73) sdp1.58398 > sdp2.pdx.zabbo.net.48004
1201046468.233456 IP (length 52) sdp2.pdx.zabbo.net.48004 > sdp1.58398
```

coherency protocol

(Simplified. No, seriously.)



security hand-waving

- currently untranslated UID/GID in the clear
- will secure transport (TLS? MAC only?)
- will inspect transactions to enforce policy
- identity and capability metadata on disk and in transactions could enable untrusted clients
- crypto on disk could let clients hide data from crfsd (maybe ecryptfs metadata?)

TODO: cris-atunity!

BTRFS multi-device support

BTRFS allocation policy

SSD tuning

man pages

incremental backups

wireshark

crfsd UNIX IO

OS X

cache coherency

automated QA

xattrs

failover

BSD

hot spare read load balancing

FS metadata crypto

snapshots

crfsd parallelism

ENOSPC credits

crfsd cache refcounting

howtos

online repair

crfs.ko cache data structure

encrypted user data

FUSE

UID mapping

crfs.ko allocation policy

SMP tuning

tcpdump

WAN tuning

transport crypto

transaction auditing

IETF

BTRFS volume resizing

statistics

binary packages

crfsd config

http://oss.oracle.com/projects/crfs/

```
$ wc -l lk/*.[ch] | tail -1
  7335 total
$ wc -l crfsd/*.[ch] | tail -1
  5971 total
```