FreeBSD Mastery: ZFS

- 1: ZFS 1
- 2:

 (Virtual Devices)
- 4. ZFS (ZFS Datasets)

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ZFS? ?????

| ZFS ?? |
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| OpenZFS (http://open-zfs.org) (mmm) |
| FreeBSD , ZFS |
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. RAID ZFS....... ZFS? ???? ?????? ____ ZFS_ ___ ZFS ___ ___ Linux _____ UFS2_ ___ __ __ __ __ __ __ __ __ __ ___ ZFS ???? ППП . RAM IIII III III III ECCI IIIII . III ZFS IIIII III III □ RAM□□ □□□ .

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| ??? ???(DiskRedundancy) |
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| ??? ???(Physical Redundancy) |
| FreeBSD |
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| FreeBSD |
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?? 1: ZFS ??

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ZFS ??? ?? (ZFS Datasets)
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           (UFS) | | | | | | | | |
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          . df(1), newfs(8), mount(8), umount(8), dump(8),
    restore(8) □ □ □
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             $ zfs list
        USED AVAIL REFER MOUNTPOINT
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        429M 13.0G
zroot
              96K none
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             96K none
zroot/ROOT/default 428M 13.0G
             428M /
zroot/tmp
        104K 13.0G
              104K
/tmp zroot/usr
          428K 13.0G
                96K /usr
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                          \square ZFS storage polol, \square
      zpool
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| REFER ZFS |
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| zroot/ROOT |
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| ZFS[] [] [] [] [] [] [] [] [] [] [] [] [] [|
| ZFS ??? ?? (ZFS partitions and properties) |
| ZFS(|
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| ZFS: |

| <pre>\$ zfs set quota=2G zroot/var/log</pre> |
|---|
| zfs get []] []] . |
| <pre>\$ zfs get quota zroot/var/log NAME PROPERTY VALUE SOURCE zroot/var/log quota 2G local</pre> |
| zfs get all ZFS |
| ZFS ??(ZFS Limits) |
| |
| ZFS |
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| ???? ? |
| ZFS: ::::::::::::::::::::::::::::::::::: |

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$ zpool status
 pool: zroot
state: ONLINE
 scan: none requested
config:
NAME
    STATE
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          0
zroot
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errors: No known data errors
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?? ?? (Virtual Devices)
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??? ??? (Blocks and Inodes)

____ ZFS__ ____ , __ ____

?? 2: ?? ?? (Virtual Devices)

??? ?? ?? ?? (Disks and Other Storage Media)

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?? ??? ??? (Raw Disk Storage)

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| GEOM: |
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| ?? ???? (File-Backed Storage) |
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| ?????? ???(Providers vs. Disks) |
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| VDEV: ?? ?? (VDEVs: Virtual Devices) |
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| RAID[] [[[]] . |
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| VDEV ??? (VDEVs Redundancy) |
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| ZFS [] [] [] VDEV[] [] [] [] [] [] [] [] [] [] [] [] [] [|
| Mirrors (2? ??? ???) |
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| RAID-Z1(3? ??? ???) |

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| RAID-Z2 RAID-Z1 | |
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| RAID-Z | Z2 |
| RAID-Z ??? ?? (RAID-Z Disk Configurations) RAID-Z RA | RAID-Z3(5? ??? ???) |
| | 3 RAID-Z2 |
| | RAID-Z ??? ?? (RAID-Z Disk Configurations) |
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| 2n+3(5n, 7n, 9n, n) |
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| VDEV ?? (Repairing VDEVs) |
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| ZFSRAID |
| RAID-Z? ?? RAID ??(RAID-Z versus Traditional RAID) |
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           ?? VDEV (Special VDEVs)
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??? ??? (Seperate Intent Log; SLOG, ZIL)
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??(Cache: L2ARC)
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  □ 2 ARC □ L2ARC□ □ .

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(12 \times 1TB) \boxed{} \boxed{}
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. _____ 1TB ____ ___
                                                     □ 100MB/s□ □ /□ /□ □
```

??? ?? (One Disk)

| Table 1. Single Disk Virtual Device Configurations | | | | | | | | |
|--|----------------------|-----------|------------|-----------|------------|----------------------|--------------------|--|
| Disks | Config | Read IOPS | Write IOPS | Read MB/s | Write MB/s | Usable | Fault | |
| 1 | Stripe | 250 | 250 | 100 | 100 | Space 1 TB (100%) | Tolerance | |
| | | | | | | | | |
| ? ?? ??? (| Two Disks | 5) | | | | | | |
| | | | | VDEV Ⅲ | | VDEV[] [] | | |
| THE CONTRACTOR OF THE CONTRACT | | | | | | | | |
| VDEV | | | | | | | | |
| Disks | Config | Read IOPS | Write IOPS | Read MB/s | Write MB/s | Usable Space | Fault Tolerance | |
| 2 | 2 x Stripe | 500 | 500 | 200 | 200 | 2 TB (100%) | none | |
| 2 | 1 x 2 disk Mirror | 500 | 250 | 200 | 100 | 1 TB (50%) | 1 | |
| | | | | | | | | |
| ??? 3? (Th | nree Disks | • | | | | | _ | |
| | | | | | | | | |
| | | | | | | | | |

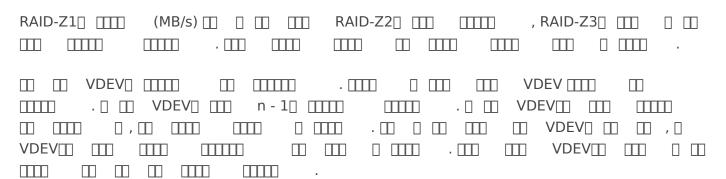
| RAID-Z10 | | | | | | | |
|------------------------------------|-----------------------|--------------|---------------|---------------|---------------|-----------------|--------------------|
| | | Table 3: Thr | ee-Disk Virtu | ial Device Co | onfigurations | | |
| Disks | Config | Read IOPS | Write IOPS | Read MB/s | Write MB/s | Usable Space | Fault Tolerance |
| 3 | 1 x 3 disk Mirror | 750 | 250 | 300 | 100 | 1 TB (33%) | 2 |
| 3 | 1 x 3 disk RAID-Z1 | 250 | 250 | 200 | 200 | 2 TB (66%) | 1 |
| | | | | | | | |
| VDEV(RAID 10) | | | | | | | |
| | | | | | | | |
| 5 RAID-Z3 . RAID-Z3 VDEV . 3 | | | | | | | |

Table 4: Four- or Five-Disk Virtual Device Configurations

☐ RAID-Z1☐ ☐ ☐ ☐ ☐ .

| Disks | Config | Read IOPS | Write IOPS | Read MB/s | Write MB/s | Usable Space | Fault Tolerance |
|-------|------------------------|-----------|------------|-----------|------------|-----------------|--------------------|
| 4 | 2 x 2 disk Mirror | 1000 | 500 | 400 | 200 | 2 TB (50%) | 2 (1/VDEV) |
| 4 | 1 x 4 disk RAIDZ-Z1 | 250 | 250 | 300 | 300 | 3 TB (75%) | 1 |

| 4 | 1 x 4 disk RAIDZ-Z2 | 250 | 250 | 200 | 200 | 2 TB (50%) | 2 |
|---|------------------------|-----|-----|-----|-----|------------|---|
| 5 | 1 x 5 disk RAIDZ-Z1 | 250 | 250 | 400 | 400 | 4 TB (80%) | 1 |
| 5 | 1 x 5 disk RAIDZ-Z2 | 250 | 250 | 300 | 300 | 3 TB (60%) | 2 |
| 5 | 1 x 5 disk RAIDZ-Z3 | 250 | 250 | 200 | 200 | 2 TB (40%) | 3 |



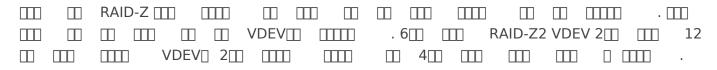
6~12?? ??? (Six to Twelve Disks)



Table 5: Six- to Twelve-Disk Virtual Device Configurations

| Disks | Config | Read IOPS | Write IOPS | Read MB/s | Write MB/s | Usable Space | Fault Tolerance |
|-------|------------------------|-----------|------------|-----------|------------|-----------------|--------------------|
| 6 | 3 x 2 disk Mirror | 1500 | 750 | 600 | 300 | 3 TB (50%) | 3 (1/VDEV) |
| 6 | 2 x 3 disk Mirror | 1500 | 500 | 600 | 200 | 2 TB (33%) | 4 (2/VDEV) |
| 6 | 1 x 6 disk RAIDZ-Z1 | 250 | 250 | 500 | 500 | 5 TB (83%) | 1 |
| 6 | 1 x 6 disk RAIDZ-Z2 | 250 | 250 | 400 | 400 | 4 TB (66%) | 2 |
| 6 | 1 x 6 disk RAIDZ-Z3 | 250 | 250 | 300 | 300 | 3 TB (50%) | 3 |

| 12 | 6 x 2 disk Mirror | 3000 | 1500 | 1200 | 600 | 6 TB (50%) | 6 (1/VDEV) |
|----|-------------------------|------|------|------|------|-------------|------------|
| 12 | 4 x 3 disk Mirror | 3000 | 1000 | 1200 | 400 | 4 TB (33%) | 8 (2/VDEV) |
| 12 | 1 x 12 disk RAIDZ-Z1 | 250 | 250 | 1100 | 1100 | 11 TB (92%) | 1 |
| 12 | 2 x 6 disk RAIDZ-Z1 | 500 | 500 | 1000 | 1000 | 10 TB (83%) | 2 (1/VDEV) |
| 12 | 3 x 4 disk RAIDZ-Z1 | 750 | 750 | 900 | 900 | 9 TB (75%) | 3 (1/VDEV) |
| 12 | 1 x 12 disk RAIDZ-Z2 | 250 | 250 | 1000 | 1000 | 10 TB (83%) | 2 |
| 12 | 2 x 6 disk RAIDZ-Z2 | 500 | 500 | 800 | 800 | 8 TB (66%) | 4 (2/VDEV) |
| 12 | 1 x 12 disk RAIDZ-Z3 | 250 | 250 | 900 | 900 | 9 TB (75%) | 3 |
| 12 | 2 x 6 disk RAIDZ-Z3 | 500 | 500 | 600 | 600 | 6 TB (50%) | 6 (3/VDEV) |



?? ??? (Many Disks)

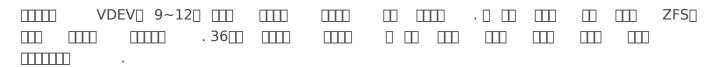


Table 5: Six- to Twelve-Disk Virtual Device Configurations

| Disks | Config | Read IOPS | Write IOPS | Read MB/s | Write MB/s | Usable Space | Fault Tolerance |
|-------|------------------------|-----------|------------|-----------|------------|-----------------|--------------------|
| 36 | 18 x 2 disk Mirror | 9000 | 4500 | 3600 | 1800 | 18 TB (50%) | 18 (1/VDEV) |
| 36 | 12 x 3 disk Mirror | 9000 | 3000 | 3600 | 1200 | 12 TB (33%) | 24 (2/VDEV) |
| 36 | 1 x 36 disk RAID-Z2 | 250 | 250 | 3400 | 3400 | 34 TB (94%) | 2 |
| 36 | 2 x 18 disk RAID-Z2 | 500 | 500 | 3200 | 3200 | 32 TB (89%) | 4 (2/VDEV) |
| 36 | 4 x 9 disk RAID-Z2 | 1000 | 1000 | 2800 | 2800 | 28 TB (78%) | 8 (2/VDEV) |

| 36 | 6 x 6 disk RAID-Z2 | 1500 | 1500 | 2400 | 2400 | 24 TB (66%) | 12 (2/VDEV) |
|-------|-----------------------|------|----------|------|--|---------------------------------------|--|
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?? 3. ?(Pools)

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?????, RAID ? ? (Stripes, RAID, and Pools)

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      \mathsf{RAID} \square \quad . \quad \square \quad \square \quad \mathsf{RAID-10} \quad \square \quad \square \quad \square \quad \square \quad \mathsf{DEV} \quad \square \quad \square \quad \square \quad .
? ?? (Viewing Pools)
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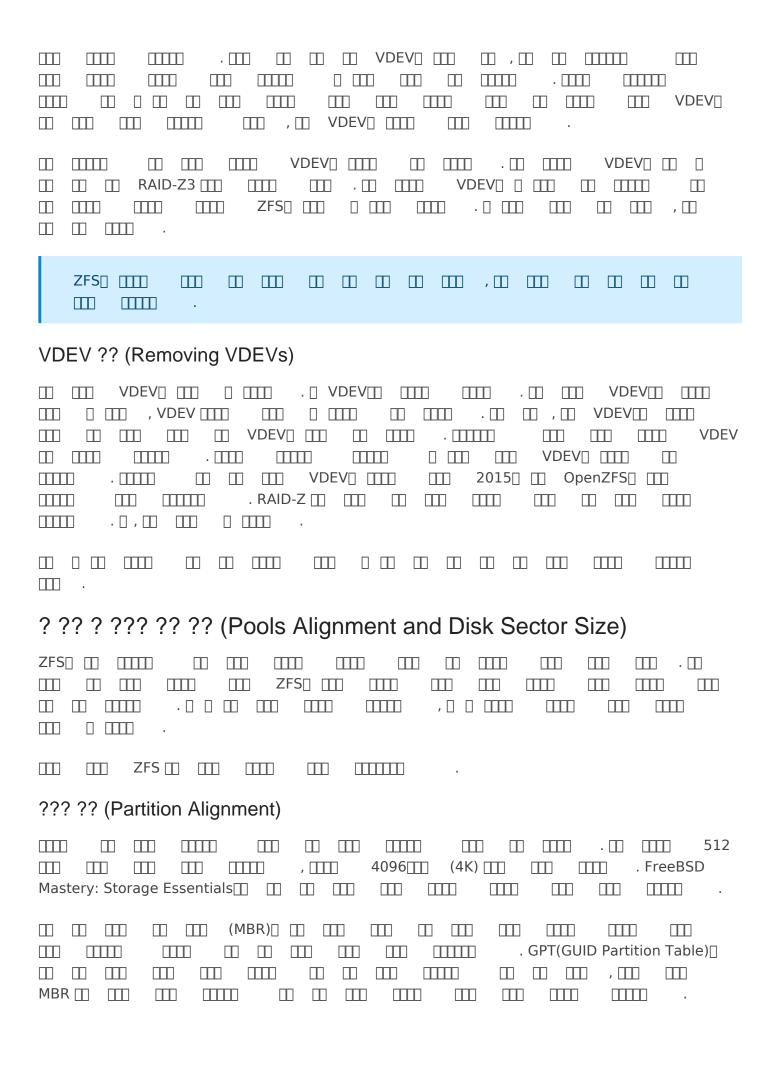
 \$ zpool list

 NAME
 SIZE
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 FRAG
 CAP
 DEDUP
 HEALTH
 ALTROOT

 db
 2.72T
 1.16G
 2.72T
 0%
 0%
 1.00x
 ONLINE

 zroot
 920G
 17.3G
 903G
 2%
 1%
 1.00x
 ONLINE

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$ zpool list -v zroot
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         zpool status | | | | | | | | |
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FreeBSD 10.1 ? ??? Ashift (FreeBSD 10.1 and Newer Ashift)

| /etc/sysctl.conf |
|--|
| <pre>\$ sysctl vfs.zfs.min_auto_ashift=12</pre> |
| |
| ☐ ☐ ☐ ☐ ☐ FreeBSD 10.1 ☐ ☐ ☐ ☐ , sysctl☐ ☐ ☐ ☐ ashift☐ ☐ ☐ ☐ . |
| ?? FreeBSD Ashift (Older FreeBSD Ashift) |
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| |
| \$ gnop create -S 4096 /dev/gpt/zfs0 |
| |
| <pre>\$ zpool create compost mirror gpt/zfs0.nop gpt/zfs1</pre> |
| gnop(8) |
| ?? ???????? (Creating Pools and VDEVs) |
| zpool(8) zpool(8) VDEV |
| |

?? ???? (Sample Drives)

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                                       gpart(8)
      ZFS IIII
              ☐ 6☐ 1TB ☐ ☐
                               $ gpart create -s gpt da0
 $ gpart add -a 1m -s1g -l sw0 -t freebsd-swap da0
 $ gpart add -a 1m -1 zfs0 -t freebsd-zfs da0
$ gpart show -l da0
      40 1953525088 da0 GPT (932G)
             2008
                  - free - (1.0M)
      40
     2048
           2097152
                  1 \text{ sw0} (1.0\text{G})
                  2 zfs0 (931G)
   2099200 1951424512
 1953523712
             1416
                  - free - (708K)
GPT [[[]]
            ZFS [ ] [ ]
                                gpt/zfs0□ gpt/zfs5□□
                         ?????? ? (Striped Pools)
        пт
П
   .
                                                          П
. 🛮 🖽
                                                 zpool create | | | | | |
                         m . mm
т т
          ПППП
                · m m
                                    ППП
                                          п п
                                                          5∏
$ sysctl vfs.zfs.min_auto_ashift=12
 $ zpool create compost gpt/zfs0 gpt/zfs1 gpt/zfs2 gpt/zfs4 gpt/zfs4
. ☐ zpool status☐ ☐ ☐
    ПППП
 $ zpool status
  pool: compost
  state: ONLINE
  scan: none requested
 config:
 NAME
        STATE READ WRITE CKSUM
 compost
        ONLINE
              0
                  0
                      0
  gpt/zfs0 ONLINE
                      0
```

| gpt/zfs1 | ONLINE | 0 | 0 | 0 | | | | | | | | |
|------------------------------|-------------------|--------|------------------|------|-----------|--------------|---------------------|---------|------|--------|--------|----|
| gpt/zfs2 | ONLINE | 0 | 0 | 0 | | | | | | | | |
| gpt/zfs3 | ONLINE | 0 | 0 | 0 | | | | | | | | |
| gpt/zfs4 | ONLINE | 0 | 0 | 0 | | | | | | | | |
| 5 | | | . 🛘 | | □ ∨ | 'DEV <u></u> |] . | | | | | |
| | , VDE | | | | | |] (III) II) (II) | VDE\ | | | | |
| ?? ? (Mirro | red Po | ols) | | | | | | | | | | |
| | | | | | | | | | | | , | |
| zpool | create [| | | | ift | mirro [] | r | | | | | |
| \$ sysctl v1 \$ zpool cre | | | | | s0 gpt/zf | s1 | | | | | | |
| zpool status | 5 [] [[] [| Ш | | | | | | | | | | |
| \$ zpool sta | atus | | | | | | | | | | | |
| pool: ref | | | | | | | | | | | | |
| state: ONL | | | | | | | | | | | | |
| scan: nor | ne reques | ted | | | | | | | | | | |
| config: | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| NAME | STATE R | EAD W | RITE CI | KSUM | | | | | | | | |
| reflect | ONLINE | 0 | 0 | 0 | | | | | | | | |
| mirror-0 | ONLINE | 0 | 0 | 0 | | | | | | | | |
| gpt/zfs0 | ONLINE | 0 | 0 | 0 | | | | | | | | |
| gpt/zfs1 | ONLINE | 0 | 0 | 0 | | | | | | | | |
| errors: No | known da | ıta er | rors | | | | | | | | | |
| | gpt/zf | fs0∏ | ·0 gpt/zi | | | | . miri | ror-0 🎹 |] VD | EVIIII | . 🛭 VD | EV |

| <pre>\$ zpool create reflect mirror gpt/zfs0 gpt/zfs1 gpt/zfs2 gpt/zfs3</pre> |
|---|
| ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ |
| RAID-Z Pools |
| |
| |
| <pre>\$ sysctl vfs.zfs.min_auto_ashift=12 \$ zpool create raidz1 gpt/zfs0 gpt/zfs1 gpt/zfs2</pre> |
| □ □ □ □ □ □ □ raidz1-0□ □ VDEV□ □ □ . |
| \$ zpool status bucket pool: bucket state: ONLINE scan: none requested config: NAME STATE READ WRITE CKSUM bucket ONLINE 0 0 0 raidzl-0 ONLINE 0 0 0 gpt/zfs0 ONLINE 0 0 0 gpt/zfs1 ONLINE 0 0 0 gpt/zfs2 ONLINE 0 0 0 |
| [] [] [] [] [] [] [] [] [] [] [] [] [] |
| <pre>\$ zpool create bucket raidz3 gpt/zfs0 gpt/zfs1 gpt/zfs2 gpt/zfs3 gpt/zfs4 gpt/zfs5</pre> |
| maidz3-0mm |
| <pre>\$ zpool status pool: bucket</pre> |

```
state: ONLINE
  scan: none requested
 config:
       STATE READ WRITE CKSUM
 NAME
 bucket
       ONLINE
 raidz3-0
      ONLINE
            0
                0
                   0
 gpt/zfs0 ONLINE 0
  gpt/zfs1 ONLINE
            0
                0
                   0
      ПП
   ПП
?? VDEV ? (Multi-VDEV Pools)
VDEV  
       . [
                   □□□ VDEV□
                    ППППП
     ПППП
          RAID-10 III IIIIII III IIII
                                  ПППП
      . ППП
           $ sysctl vfs.zfs.min auto ashift=12
 $ zpool create barrel mirror gpt/zfs0 gpt/zfs1 mirror gpt/zfs2 gpt/zfs3
       zpool create barrel zpool(8) barrel control
                                   . mirror IIII
              \cdot \square \square \square
□ gpt/zfs1□ □□□
                      . mirror∏ ∏
                П
     □ VDEV□ □□□
                □ VDEVⅢ ⅢⅢ
                              ☐ zpool(8)☐ ☐ ☐ VDEV
          ПП
$ zpool status barrel
 pool: barrel
 state: ONLINE
  scan: none requested
 config:
 NAME
      STATE READ WRITE CKSUM
 barrel
      ONLINE
           0
                  0
 mirror-0 ONLINE
           0
  gpt/zfs0 ONLINE 0
               0
                  0
  gpt/zfs1 ONLINE 0
              0
                  0
```

```
mirror-1 ONLINE
  gpt/zfs2 ONLINE
  gpt/zfs3 ONLINE
. ZFS□ □ VDEV□ □
            RAID-10∏∏ . ∏∏∏
VDEV III IIII
                             . FreeBSD[] [[]
                 RAID IIII
                       RAID[] [[[]]
                                             RAID
ППП
    \Pi
                    . [ ] RAID-Z1 VDEV [ ] [ ]
ППППП
       $ zpool create vat raidz1 gpt/zfs0 gpt/zfs1 gpt/zfs2 raidz1 gpt/zfs3 gpt/zfs4 gpt/zfs5
□ □ RAID-Z1 VDEV□ □ □ □ □ □ □
                          , ☐ gpt/zfs0, gpt/zfs1, gpt/zfs2☐ ☐☐☐☐
    ППП
                          . zpool 📗 🔲 👚 👚
        . ____ RAID-Z ____
$ zpool status vat
 config:
 NAME
      STATE READ WRITE CKSUM
      ONLINE
           0
 vat
 raidz1-0 ONLINE
  gpt/zfs0 ONLINE 0
                  0
  gpt/zfs1 ONLINE 0
                  0
  gpt/zfs2 ONLINE
 raidz1-1 ONLINE
  gpt/zfs3 ONLINE
  gpt/zfs4 ONLINE
           0
               0
                  0
  gpt/zfs5 ONLINE
□ VDEV□ □
          □ VDEV□ □□□
   RAIDZ∏
, 🔲
                                  □ RAIDZ □□ □□
ППП
     ПП
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                          пт
                                             П
VDEV
       □ VDEV □ □□□□
                             . .
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                                             ПП
                           U VDEV U U VDEV U VDEV
                                                 IOPS
          , ....
```

?? ?? ?? (Using Log Devices)

| 2 |
|--|
| <pre>\$ zpool create scratch gpt/zfs0 log gtp/zlog0 cache gpt/zcache1</pre> |
| |
| <pre>\$ zpool status scratch config:</pre> |
| NAME STATE READ WRITE CKSUM |
| scratch ONLINE 0 0 0 |
| gpt/zfs0 ONLINE 0 0 0 |
| logs gpt/zlog0 ONLINE 0 0 0 cache |
| gpt/zcachel ONLINE 0 0 |
| |
| <pre>\$ zpool create db mirror gpt/zfs0 gpt/zfs1 mirror gpt/zfs2 gpt/zfs3 log mirror gpt/zlog0 gpt/zlog1</pre> |
| |
| ???? ?? VDEV (Mismatched VDEVs) |
| VDEV , zpool(8) |
| <pre>\$ zpool create daftie raidz gpt/zfs0 gpt/zfs1 gpt/zfs2 mirror gpt/zfs3 gpt/zfs4 gpt/zfs5 invalid vdev specification use '-f' to override the following errors:</pre> |

| mismatched replication level: both raidz and mirror vdevs are present |
|---|
| zpool(8) |
| ZFS: |
| ???? (Reusing Providers) |
| |
| <pre>\$ zpool create db gpt/zfs1 gpt/zfs2 gpt/zfs3 gpt/zfs4 invalid vdev specification use '-f' to override the following errors: /dev/gpt/zfs3 is part of exported pool 'db'</pre> |
| 0 |
| 0 |
| <pre>\$ zpool create -f db gpt/zfs1 gpt/zfs2 gpt/zfs3 gpt/zfs4</pre> |
| ZFSf create |
| ? ??? (Pool Integrity) |
| ZFS: :: :: :: :: :: :: :: :: :: :: :: :: : |
| ZFS ??? (ZFS Integrity) |
| |

| ZFS: ::::::::::::::::::::::::::::::::::: |
|---|
| VDEV |
| |
| ZFS: |
| |
| Scrubbing ZFS |
| ZFS (scrub) |
| |
| <pre>scan: scrub repaired 0 in 15h57m with 0 errors on Sun Feb 8 15:57:55 2015 errors: No known data errors</pre> |
| |

```
$ zpool scrub zroot
. zpool status 🛛 🎹
   $ zpool status
scan: scrub in progress since Tue Feb 24 11:52:23 2015
12.8G scanned out of 17.3G at 23.0M/s, 0h3m to go
0 repaired, 74.08% done
. . .
ZFS \square
            .
                          . 🔲
                    $ zpool scrub -s zroot
??? ?? (Scrub Frequency)
ZFS[] [[[]]
    . 🛮 , 🔲 🗀
                . 🔲
               . 🔲
                     \Pi .
      ___ "ZFS ___ __ __
               ☐ FreeBSD☐ ☐☐☐
ППП
                              ? ?? (Pool Properties)
П
         . zpool III
                      П
                               ПП
, 🔲
                      . 🛮 🔲
       ПП
          ПП
? ?? ?? (Viewing Pool Properties)
               zroot II II III
$ zpool get all zroot
NAME
   PROPERTY VALUE
          SOURCE
```

```
zroot capacity 1%
zroot altroot - default
zroot health
      ONLINE -
. . .
.
920G[], [] [[] 920GB[] [[]
SOURCE [ ] [
        \cdot \square \square \square \square
            . FreeBSD[] [[[]
                                . ____
       , 📖
                            ☐ ☐ ☐ Zpool get☐ ☐ ☐
$ zpool get size
NAME PROPERTY VALUE SOURCE
       2.72T -
db
   size
      920G -
zroot size
? ?? ?? (Changing Pool Properties)

    □ comment □□

. .
               $ zpool set comment="Main OS files" zroot
$ zpool get comment
   PROPERTY VALUE
NAME
            SOURCE
db
   comment -
            default
zroot comment Main OS files local
SOURCE III IIIIII
          . .
               . .
                          .
```

zroot size 920G

```
$ zpool set comment="-" zroot
 # zpool get comment
 NAME
     PROPERTY VALUE SOURCE
 db
     comment
                default
 zroot comment
                local
\cdot \square \square
                                                        -O□
□ -o□ □
               ПП
   $ zpool create -o altroot=/mnt -O canmount=off -m none zroot /dev/gpt/disk0
    altroot ∏∏
             /mnt□ □□□
                        canmount ||||
                                                      off∏
.
                П
                ППП
                      ? ???? (Pool History)
  . 🛮 🔲
               ПП
      , 🔲
                                                     , 🔲
                                                           П
ПП
    ППП
ПП
            zpool history
☐ ☐ ☐ ☐ ☐
                            ПППП
                                  $ zpool history zroot
 History for 'zroot':
 2014-01-07.04:12:05 zpool create -o altroot=/mnt -0 canmount=off -m none zroot mirror /
 dev/gpt/disk0.nop /dev/gpt/disk1.nop
 2014-01-07.04:12:50 zfs set checksum=fletcher4 zroot
 2014-01-07.04:13:00 zfs set atime=off zroot
    FreeBSD IIII
                FreeBSD IIII
ZFS IIII
                                               2015-03-12.14:36:35 zpool set comment=Main OS files zroot
 2015-03-12.14:43:45 zpool set comment=- zroot
comment ||||
```

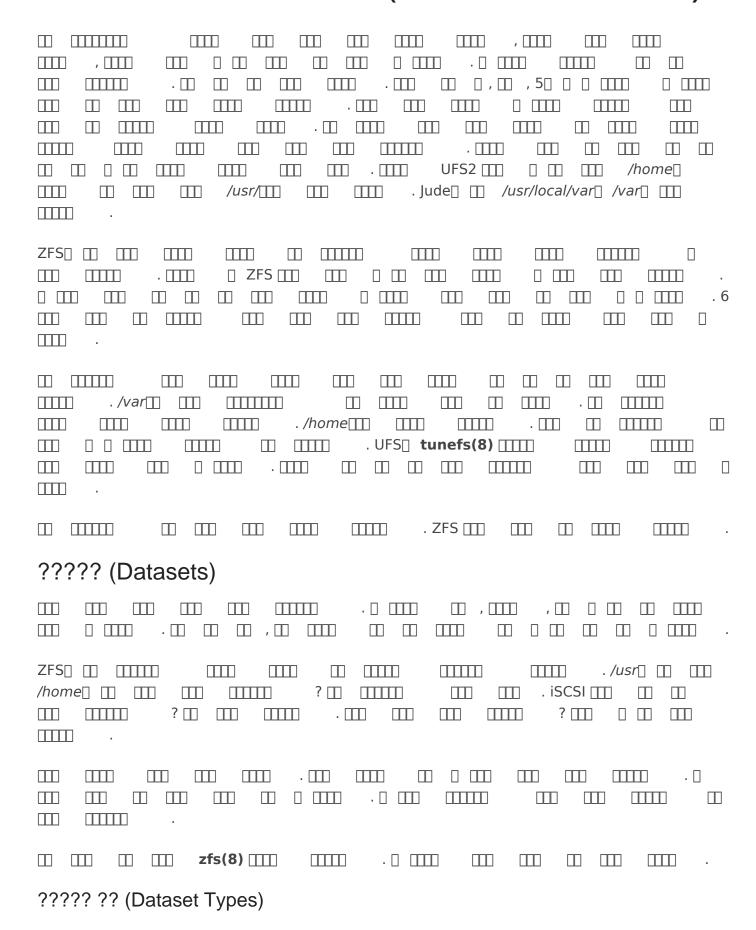
| Zpool ?? ??? (Zpool Maintenance Automation) |
|---|
| FreeBSD[] periodic(8)[] [] [] [] [] [] [] [] [] [] [] [] [] [|
| daily_status_zfs_enable="YES" |
| ☐ ☐ periodic(8) ☐ ☐ ☐ ☐ Zpool status -x ☐ ☐ ☐ ☐ ☐ Zpool status -x ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ |
| |
| FreeBSD[] [] [] [] [] [] [] [] [] [] [] [] [] [|
| daily_scrub_zfs_enable="YES" |
| FreeBSD[] [] [] [] [] [] [] [] [] [] [] [] [] [|
| daily_scrub_zfs_pools="zroot prod test" |
| |
| daily_scrub_zfs_default_threshold="10" |
| |
| daily_scrub_zfs_prod_threshold="7" |
| |
| ? ?? (Removing Pools) |
| zpool destroy |

```
, 5□□
        Zpool ?? ??? (Zpool Feature Flags)
    П ПП
       . . .
                          ZFS [ 20 [
       ."□
.
    ZFS III
        , 🔲
             ZFS IIII
                         ZFS IIII
                 28
   . .
        . .
                        \cdot \square \square
  , □ □ FooZFS □ 30□ BarZFS □ 30□ □□□
. ZFS | | | | |
           OpenZFS II II III
                       OpenZFS III
       5000Ⅲ
            OpenZFS IIII
. [
                 OpenZFS[] [[[[]]
             ППП
                         zpool-features(7) IIII
        FreeBSD[] [[]]
                            ПП
  ПП
    "
       ."...
                ПП
                            . ПП
        \cdot 0 00 000
                              . .
              \square , \square
                        ?????? (Viewing Feature Flags)
"feature"∭
                    $ zpool get all zroot | grep feature
zroot feature@async_destroy enabled
zroot feature@empty_bpobj
          active
             local
zroot feature@lz4_compress
          active
             local
```

\$ zpool destroy test

| The compatible in the compatib |
|--|
| |
| |

?? 4. ZFS ???? (ZFS Datasets)

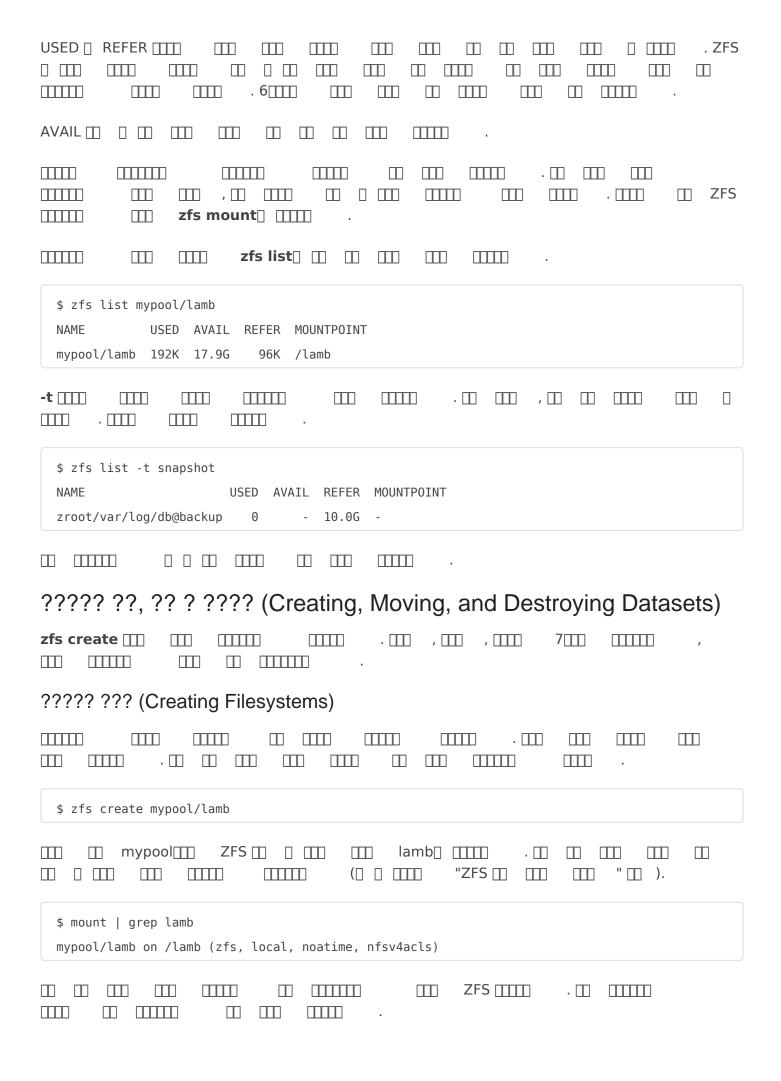


```
\square ZFS\square (filesystems), \square (volumes), \square (snapshots), \square (clones), \square
ППППП
  ПП
    \square , chflags(2) \square \square \square
     UFS IIII
          П
  ППП
          ППП
          ПП
            ПП
             ??? ??? ??? ?????? (Why Do I Want Datasets?)
  ПП
 □ ZFS □□
   \mathsf{m} \mathsf{m}
  \cdot \square \square \square \square \square \square \square \square
         ППП
             ПП П
\Pi
  ППП
 .
ППП
  \mathsf{m} \mathsf{m}
  ППП
 ☐ ☐ /webserver ☐ ☐
ППП
```

□□ ? ПП ПП ППП ? П П ПП ППП п п ппп ПП ПП ПП ПППП . ____ ZFS_ ___ ___ ___ ___ ___ ____ \$ zfs list USED AVAIL REFER MOUNTPOINT NAME 420M 17.9G 96K none mypool/ROOT 418M 17.9G 96K none

418M /

mypool/ROOT/default 418M 17.9G



| <pre>\$ zfs create mypool/lamb/baby</pre> |
|--|
| |
| ?? ??? (Creating Volumes) |
| -V |
| \$ zfs create -V 4G mypool/avolume |
| Zvols :t volume : zfs list |
| \$ zfs list mypool/avolume NAME USED AVAIL REFER MOUNTPOINT ypool/avolume 4.13G 17.9G 64K - |
| Z[] [] ZFS [] [] [] [] [] . [] 4GB zvol[4.13GB[|
| |
| \$ ls -al /dev/zvol/mypool/avolume crw-r 1 root operator 0x4d Mar 27 20:22 /dev/zvol/mypool/avolume |
| |
| ????? ?? (Renaming Datasets) |
| |
| <pre>\$ zfs rename db/production db/old \$ zfs rename db/testing db/production</pre> |
| |
| |

| ????? ???? (Moving Datasets) |
|---|
| |
| |
| <pre>\$ zfs rename zroot/var/db/mysql zroot/important/mysql</pre> |
| |
| |
| ????? ???? (Destroying Datasets) |
| |
| \$ zfs destroy db/old |
| -r |
| |
| ZFS ?? (ZFS Properties) |
| ZFS |
| |
| ?? ?? (Viewing Properties) |
| zfs(8) |

| NAME PROPERTY VALUE SOURCE mypool/lamb compression lz4 inherited from mypool |
|--|
| NAME |
| SOURCE |
| |
| |
| \$ zfs get all mypool/lamb NAME PROPERTY VALUE SOURCE mypool/lamb type filesystem - mypool/lamb creation Fri Mar 27 20:05 2015 - mypool/lamb used 192K - |
| all |
| \$ zfs get quota,reservation zroot/home NAME PROPERTY VALUE SOURCE zroot/home quota none local zroot/home reservation none default |
| zfs list[] -o []]] |
| \$ zfs list -o name,quota,reservation NAME QUOTA RESERV db none none zroot none none zroot/ROOT none none zroot/ROOT/default none none |

\$ zfs get compression mypool/lamb

```
100G
             20G
 zroot/var/log
?? ?? (Changing Properties)
         ППП
                                 .
      ПП
compression III
        off[] []
 $ zfs set compression=off mypool/lamb/baby
zfs getⅢ Ⅲ Ⅲ
         $ zfs get compression mypool/lamb/baby
        PROPERTY
NAME
              VALUE SOURCE
mypool/lamb/baby compression off
                 local
                         . compression III
ZFS[] [[[[]]]
                       6Ⅲ
 ППП
                . .
                    . ПП
                                  .
                         ППП
   ППП
       \Pi\Pi\Pi
              .
                ППП
                    ПП
                       ПП
                          ППП
                              ПП
                                   П
                                    . 🗆 🚥
      zfs IIII
                 ?? ?? (Read-Only Properties)
. .
                                . "
            ."[
                    ZFS Ⅲ
   . (6
             П
              .) creation III
                               П
.
                     П
       ?? ??? ?? (Filesystem Properties)
 . 🔲
                                   noexec IIII
П
     . ZFS 🛮 🔛
          . .
                             ПППП
    atime
                   . ZFS□ atime Ш
atime[] [[[
         ПП
  ППП
             .
                 on∏ ∏∏
                      atime IIIII
     . atime 🛮 🔠 🔠
```

| atime] |
|--|
| exec |
| exec |
| |
| readonly |
| |
| setuid |
| |
| ☐☐☐ setuid ☐☐☐ ☐☐☐ . ☐☐☐ ☐☐ setuid ☐☐☐☐☐ . ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ |
| ZFS[] setuid []] setuid []] . on [] []] setuid [] . off |
| ??? ?? (User-Defined Properties) |
| |
| |

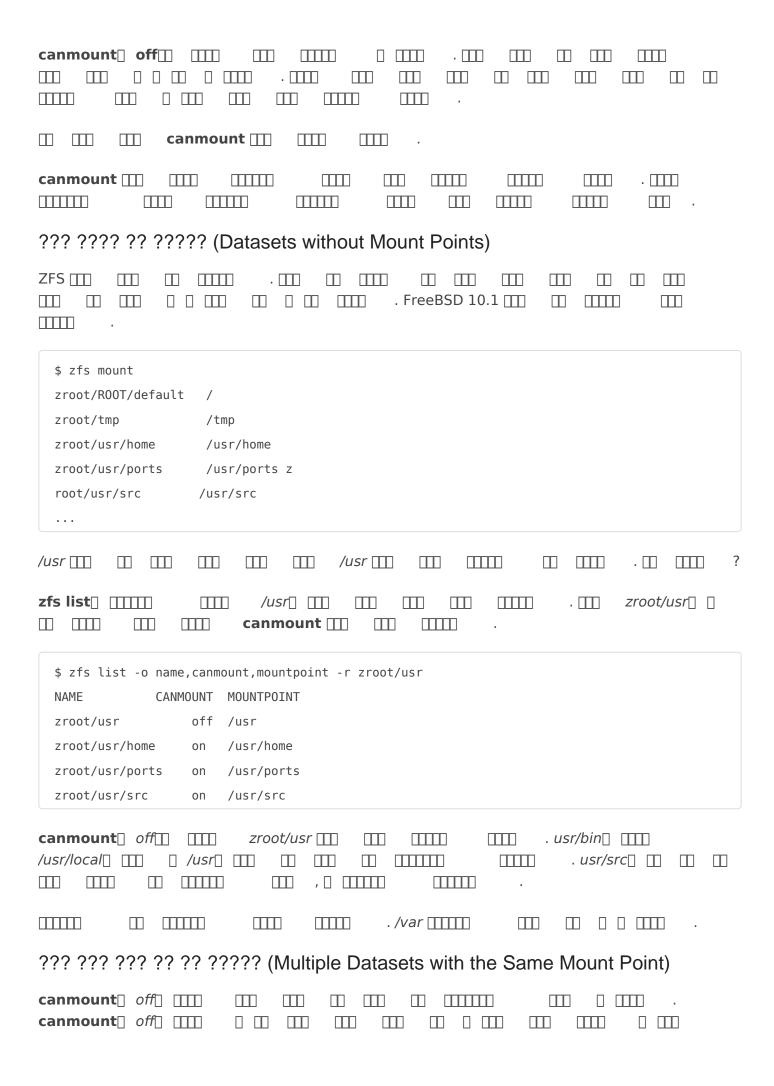
| <pre>\$ zfs set com.allanjude:backup_ignore=on mypool/lamb</pre> |
|--|
| Jude |
| ??/?? ?? (Parent/Child Relationships) |
| |
| \$ zfs get -r compression mypool/lamb NAME PROPERTY VALUE SOURCE mypool/lamb compression lz4 inherited from mypool mypool/lamb/baby compression off local |
| |
| A of a dalacet to a superation where the first the first |
| <pre>\$ zfs inherit compression mypool/lamb/baby \$ zfs get -r compression mypool/lamb</pre> |
| NAME PROPERTY VALUE SOURCE |
| mypool/lamb compression lz4 inherited from mypool |
| mypool/lamb/baby compression lz4 inherited from mypool |
| |
| <pre>\$ zfs set compression=gzip-9 mypool/lamb</pre> |
| <pre>\$ zfs get -r compression mypool/lamb</pre> |

| mypool/lamb compression gzip-9 local mypool/lamb/baby compression gzip-9 inherited from mypool/lamb |
|--|
| |
| ?? ?? ?? (Inheritance and Renaming) |
| |
| |
| <pre>\$ zfs create mypool/second \$ zfs get compress mypool/second NAME PROPERTY VALUE SOURCE mypool/second compression lz4 inherited from mypool</pre> |
| baby gzip-9 mypool/lamb baby second |
| <pre>\$ zfs rename mypool/lamb/baby mypool/second/baby \$ zfs get -r compression mypool/second NAME</pre> |
| |
| |
| ?? ?? (Removing Properties) |
| |
| |
| <pre>\$ zfs inherit com.allanjude:backup_ignore mypool/lamb</pre> |
| |

NAME

PROPERTY VALUE SOURCE

| \$ zfs inherit -r compression mypool |
|---|
| |
| ZFS ????? ????? (Mounting ZFS Filesystems) |
| [] [] [] [] [] [] [] [] [] [] [] [] [] [|
| ZFS mountpoint |
| <pre>\$ zfs get mountpoint zroot/usr/home NAME PROPERTY</pre> |
| |
| |
| |
| |
| |
| canmount noauto |



| FreeBSD |
|---|
| |
| |
| <pre>\$ zfs create db/programs # zfs create db/data</pre> |
| |
| <pre>\$ zfs set canmount=off db/programs \$ zfs set mountpoint=/opt db/programs</pre> |
| |
| <pre>\$ zfs set readonly=on db/programs</pre> |
| db/data |
| <pre>\$ zfs set canmount=off db/data \$ zfs set mountpoint=/opt db/data \$ zfs set setuid=off db/data \$ zfs set exec=off db/data</pre> |
| |
| <pre>\$ zfs create db/programs/bin \$ zfs create db/programs/sbin \$ zfs create db/data/test \$ zfs create db/data/production</pre> |
| |

| ??? ???? ?? (Pools without Mount Points) |
|--|
| |
| \$ zfs set mountpoint=none mypool |
| O O O O O O O O O O O O O O O O O O O |
| <pre>\$ zfs set mountpoint=/someplace mypool/lamb</pre> |
| |
| ???? ?? ??? ???? ???? (Manually Mounting and Unmounting Filesystems) |
| ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ |
| \$ zfs mount mypool/usr/src |
| |
| \$ zfs unmount mypool/second |
| |
| <pre>\$ zfs mount -o mountpoint=/mnt mypool/lamb</pre> |
| |
| ZFS ? /etc/fstab (ZFS and /etc/fstab) |
| |
| <pre>\$ zfs set mountpoint=legacy mypool/second</pre> |
| |

| <pre>\$ mount -t zfs mypool/second /tmp/second</pre> |
|---|
| |
| scratch/junk /tmp nosuid 2 0 |
| |
| ZFS ?? ?? (Tweaking ZFS Volumes) |
| Zvol |
| ?? ?? (Space Reservations) |
| zvol volsize |
| |
| Zvol (thin provisioning) (sparse volumes) (m) (m) |
| |
| zfs create -Vs |
| Zvol ?? (Zvol Mode) |
| FreeBSD[|

| Wolmode dev |
|---|
| volmode none |
| volmode default |
| |
| ????? ??? (Dataset Integrity) |
| ZFS; ;; ;; ;; ;; ;; ;; ;; ;; ;; ;; ;; ;; ; |
| ??? (Checksums) |
| ZFS[] [] [] [] [] [] [] [] [] [] [] [] [] [|
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| off [] [] [] [] [] . |
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| \square (deduplication) \square \square sha256 \square \square \square \square . |
|---|
| ??? (Copies) |
| ZFS0 |
| |
| |
| <pre>\$ dd if=/dev/random of=/lamb/random1 bs=1m count=10 10+0 records in 10+0 records out 10485760 bytes transferred in 0.144787 secs (72421935 bytes/sec) \$ zfs set copies=2 mypool/lamb</pre> |
| |
| \$ zfs list mypool/lamb NAME USED AVAIL REFER MOUNTPOINT mypool/lamb 10.2M 13.7G 10.1M /lamb |
| 10MB 10MB |
| <pre>\$ dd if=/dev/random of=/lamb/random2 bs=1m count=10 10+0 records in 10+0 records out 10485760 bytes transferred in 0.141795 secs (73950181 bytes/sec)</pre> |
| |
| \$ zfs list mypool/lamb NAME USED AVAIL REFER MOUNTPOINT |

mypool/lamb 30.2M 13.7G 30.1M /lamb

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