Using Boot Environments at Scale

Allan Jude – allanjude@freebsd.org
Klara Systems
Introduction

- FreeBSD Server Admin since 2001
- 4 Years as FreeBSD committer
  - ZFS, installer, boot loader, GELI (FDE)
- FreeBSD Core Team (2016 - Present)
- Co-Author of “FreeBSD Mastery: ZFS” and “FreeBSD Mastery: Advanced ZFS” with Michael W. Lucas – ZFSBook.com
- Host of BSDNow.tv Podcast
- GSoC Mentor for beectl(8)
What is a Boot Environment (BE)

- Similar in concept to NanoBSD
  - Divides the disk into 2 partitions (firmware images)
  - Install the stock image to both
  - At upgrade time, overwrite the inactive image
  - Boot-once to the newer image. If it fails, or is otherwise unserviceable, reboot to good image
  - If the new image is accepted, configure it as the default for all future reboots
  - Repeat process for next upgrade
ZFS Boot Environments

- ZFS takes this concept further
- ZFS allows you to have many filesystems, without needing to partition your disk
- Separate the OS (root FS) from user data (home directories, logs, databases)
- ZFS has instant snapshots and clones
- Snapshot and clone the root filesystem before you make changes or upgrade
How?

- Now you have multiple different ‘versions’ of your root filesystem to choose from.
- Modern FreeBSD boot loader allows you to choose from different rootfs at boot.
- Now you can ‘revert’ an upgrade without losing changes to home directories, logs, databases or other filesystems, further separating the ‘OS’ from the ‘Data’.
The flexibility of ZFS puts you in control

- Any files in the filesystem mounted as / are treated as part of the operating system
- Any files in other filesystems, are retained, no matter what ‘version’ of the OS you boot
- Packages (/usr/local) and the pkg database (/var/db/pkg) are included in /. This allows you to ‘undo’ a pkg upgrade
<table>
<thead>
<tr>
<th>NAME</th>
<th>USED</th>
<th>REFER</th>
<th>MOUNTPOINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>zroot</td>
<td>19.5G</td>
<td>88K</td>
<td>/zroot</td>
</tr>
<tr>
<td>zroot/ROOT</td>
<td>1.67G</td>
<td>88K</td>
<td>none</td>
</tr>
<tr>
<td>zroot/ROOT/default</td>
<td>1.67G</td>
<td>1.67G</td>
<td>/</td>
</tr>
<tr>
<td>zroot/tmp</td>
<td>88K</td>
<td>88K</td>
<td>/tmp</td>
</tr>
<tr>
<td><strong>zroot/usr</strong></td>
<td><strong>12.3G</strong></td>
<td><strong>88K</strong></td>
<td><strong>/usr</strong></td>
</tr>
<tr>
<td>zroot/usr/obj</td>
<td>12.3G</td>
<td>8.03G</td>
<td>/usr/obj</td>
</tr>
<tr>
<td>zroot/usr/home</td>
<td>140M</td>
<td>140M</td>
<td>/usr/home</td>
</tr>
<tr>
<td><strong>zroot/var</strong></td>
<td><strong>153M</strong></td>
<td><strong>88K</strong></td>
<td><strong>/var</strong></td>
</tr>
<tr>
<td>zroot/var/audit</td>
<td>88K</td>
<td>88K</td>
<td>/var/audit</td>
</tr>
<tr>
<td>zroot/var/crash</td>
<td>152M</td>
<td>152M</td>
<td>/var/crash</td>
</tr>
<tr>
<td>zroot/var/log</td>
<td>352K</td>
<td>352K</td>
<td>/var/log</td>
</tr>
<tr>
<td>zroot/var/mail</td>
<td>132K</td>
<td>132K</td>
<td>/var/mail</td>
</tr>
<tr>
<td>zroot/var/tmp</td>
<td>88K</td>
<td>88K</td>
<td>/var/tmp</td>
</tr>
</tbody>
</table>
That’s Great, But I Already Knew That
When upgrading a system, we wanted to replace the entire OS with a newer version. So we just install a new boot environment. But what about /etc? My machine needs to have a configured network for puppet to replace the rest of the configuration. Let’s make /etc its own filesystem, it can persist through the upgrade this way.
What Could Possibly Go Wrong?
Not So Fast...

- A lot of boot things depend upon /etc
- No /etc/fstab, no /etc/rc, no /etc/ttys
- Don’t want to etcupdate or mergemaster
- Another Idea: Steal from NanoBSD: A read-only /etc recreated at boot from /cfg
- Then learned about init_script see loader(8)
- Use init_script to mount /cfg. Replace persistent files in /etc with symlinks to /cfg
mount -p | while read _dev _mp _type _rest;
do
    [ $_mp = "/" ] || continue
    if [ $_type = "zfs" ] ; then
        pool=${_dev%%/*}
        zfs mount ${pool}/cfg
    fi
break
done
So how does that work?

- /cfg populated with ~10 files we care about
- Configure network (rc.conf.*), sysctls, SSHd keys, fstab (for jails), etc
- Rest of /etc can be replaced with stock files
- Never have to merge /etc/rc.d files
- Originally had to manually recreate symlinks because our BE images were stock
- Used a VM and a script to make new BEs
How do you deploy a Boot Env?

1. Create an image:
   a. `zfs snapshot zroot/ROOT/bename@snapname`
   b. `zfs send -pec zroot/ROOT/bename@snapname | xz -T0 -9 > bename.zfs.xz`

2. Apply the image:
   a. `fetch -o - https://svr/bename.zfs.xz | unxz | zfs recv zroot/ROOT/newbe`

3. Boot Once:
   a. `zfsbootcfg zfs:zroot/ROOT/newbe:`
Shortcomings

- We were still doing `pkg upgrade -f` in a chroot for the base system BE plus each jail
- Building images was painfully manual
- Missing a step or file almost every time
- Bootstrapping a fresh install was still a bunch of manual work, over slow IPMI
- Not usable by anyone else, too many rough edges and sharp corners
Using BEs at Scale

- Over 100 servers, 38 DCs, 11 countries
- Only myself and 1 full time sysadmin
- Mix of versions, 10.4, 11.1, 12-CURRENT
- `freebsd-update upgrade` too manual
- `zfs recv; zfsbootcfg; reboot` takes less than a minute, and fails gracefully
- Upgrade remote machines with confidence even without console access
Not Just For Packages Anymore

- Poudriere is the tool used to build the official FreeBSD binary packages, very quickly
- Uses Jails, and optionally ZFS and TMPFS
- Starts 1 jail per core, builds one package in each jail, only dependencies installed, no network
- You can use it to build your own customized package (ports tree * freebsd version * arch * set)
- Supports: iso, iso+(z)mfs, usb, usb+(z)mfs, rawdisk, zfsrawdisk, tar, firmware, embedded
A Better Way to Build

- During the development of this upgrade procedure, I happened to be talking with Baptiste Daroussin (bapt@) who informed me of his work on poudriere image.
- Designed to create customized VM or USB images. Used at Gandi to build FreeBSD images for their Public Cloud Customers.
- Supports overlays and preinstalled packages.
After discussing it, we decided that `zfs send` should be added as an output format.

- Add `-t zfssend` (full pool replication stream) and `-t zfssend+be` (just the BE).

- Modified overlay support to handle symlinks.

- Added support for a ‘ZFS Layout’ config file, in the same format used by `bsdinstall`.

- Control what files are part of the Boot Env.
What About Brand New Systems?

- Previously, we used IPMI Remote Media feature to run bootonly.iso on each machine and manually ran through `bsdinstall`.
- No PXEBOOT with only 1-3 servers per DC.
- Now we make our own iso+mfs image.
- Prompts for some config details (no DHCP).
- Partition disks and create an empty pool.
- Then `zfs recv` a full pool image on to it.
Poudriere Image for Everyone

- Many recent enhancements upstreamed
- Work-in-Progress can be found on my github
- Use it to create your own custom images
- Builds from poudriere jails you have already created to build packages. Can create from releases without having to compile!
- New Image Formats? vmdk, qcow2, vhd, MBR (CSM & EFI), GPT (CSM, EFI, both), <yours>
Enhancing Poudriere Image

- Needs better naming for image types
- Should support many more combinations
- Replace tools/boot/rootgen.sh
- Should integrate various ‘Cloudware’
- Replicate features of ‘release’ building bits
- Support for post-build scripts (chroot)
- More appliance building features - talk to me
- What features do you need?
Improvements to Come

• Automate the process of confirming an image is good, some combination of:
  ○ Uptime, Minimum level of served, self-tests

• Use `bectl` or `libbe` to set the shiny new boot environment as the default for future boots

• Extend `zfsbootcfg`
  ○ Currently just a string
  ○ Delphix uses failure count down. If counter reaches zero, boots into a phone-home rescue mode
  ○ Use a structured format to support both and more
Nested Boot Environments

- The stretch goal of the bectl(8) project was to add support for ‘nested’ BEs (bdrewery style)
- Example: have a /usr/src that matches the running kernel/world in each boot environment
- Would like better support for recursive cloning (ZFS Channel Program would be great for this)
- What filesystems would you like separate from the root FS, but part of the boot environment?
What Are Your Questions?
BSDNow.tv

- Weekly video podcast about the latest news in the BSD and IllumOS world
- Always looking for developers to interview
- Our archives are full of goodies (100+ Interviews):
  - Matt Ahrens
  - George Wilson
  - Bryan Cantrill
  - Adam Leventhal
  - Richard Yao
  - Alex Reese
  - Kirk McKusick
  - Josh Paetzel
  - Justin Gibbs
  - Paweł Jakub Dawidek
  - Sean Chittenden
  - Ryan Zezeski