

# Linux Bootloaders on System z

## Current and Future Implementations

Session 16432

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# Agenda

- Boot Process on System Z
  - Initial Program Load (IPL)
  - zIPL and limitations
  - Grub 2 function
  - Grub 2 s390 implementation
- Btrfs Intergration
- Demo





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# IPL Process

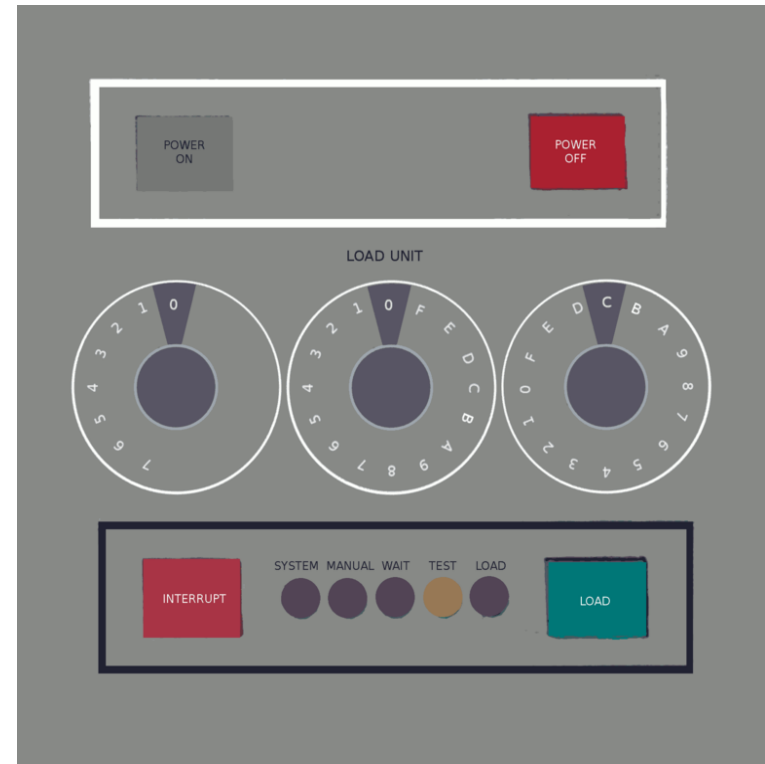
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# Initial Program Load (IPL)

- Formalized with System 360
  - Set the dials, push the button
- Initiated from CP console for z/VM or via HMC
- 1 PSW and 2 CCW loaded from
  - That's enough to load a Command Program



# Linux Initial Program Load (zipl)

- Linux bootloader for System z → zipl
- Configured with `/etc/zipl.conf`
- Bootloader is written to disk using `/sbin/zipl`

# ziPL Configuration file

## /etc/zipl.conf

```
[defaultboot]
defaultmenu = menu
```

```
[SLES11_SP3]
image = /boot/image-3.0.76-0.11-default
target = /boot/zipl
ramdisk = /boot/initrd-3.0.76-0.11-default,0x2000000
parameters = "root=/dev/dasda2 TERM=dumb resume=/dev/dasda1"
```

```
:menu
default = 1
prompt = 1
target = /boot/zipl
timeout = 10
1 = SLES11_SP3
```

# zIPL Operation

- Multi-stage operation
  - Stage 0 – 24 bytes – 2 CCWs to load and TIC to Stage 1
  - Stage 1 – 104 byte channel program to load Stage 1b
  - Stage 1b – 1k channel program to load Stage 2
  - Stage 2 – 8k maximum menu and kernel loader
  - Stage 3 – Kernel parameter parser and execution

# ZIPL Limitations - Devices

- Limited device capabilities
  - Restricted to specific Channel I/O device types
    - DASD
    - SCSI
    - Tape
  - Boot from the Network? Nope.
  - Device-mapper tends to be finicky



# zIPL Limitations – File Systems

- Limited file system support
  - Only ext2, ext3
  - Btrfs and XFS not supported

# Grub 2 on System z

# Challenges of Grub 2 on System z

- Large binary size
  - 1.3MB cannot be easily loaded via CCW
- Unique System z drivers
  - DASD, zFCP, QETH all should be cleanly implemented
  - Maintenance a major factor
- Unique display configuration
  - Both 3270 and 3215 need to be supported

# Solution: grub2-emu

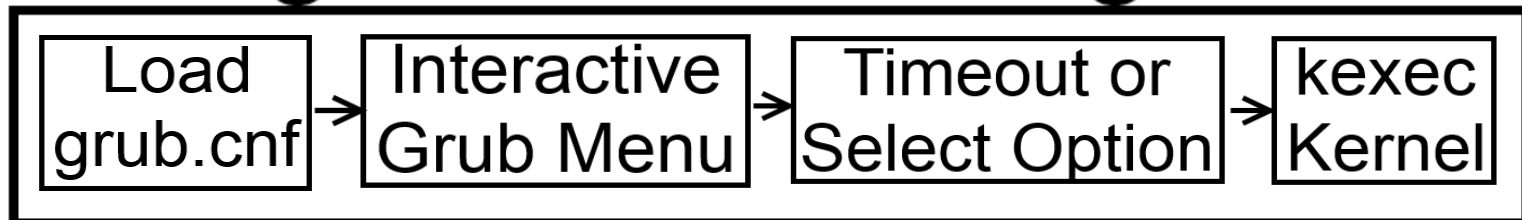
- User-mode grub2
  - Relatively little modification necessary
- Requires a linux kernel to be booted
  - All supported s390x drivers available
  - udev resolves devices
  - Still uses zIPL, but in a “Stage 4” role
- Full filesystem support
  - BTRFS snapshots
  - Unusual device-mapper configurations
- Two stage boot

# Grub 2 Boot Process

## zIPL Stage



## grub2-emu Stage



# How to boot another kernel?

- kexec
  - Kernel-supported reboot
  - Safe shutdown and restart of devices
- Implementation of kexec in Grub 2
  - New feature for grub2-emu
  - Options for kernel and initrd are used and verified
  - Only available to root user

# Configuration: grub2

- Special grub2 boot partition
  - Normally mounted to /boot/zipl
- Contains grub2 kernel and initrd
- Contains grub2 config file
  - Allows for dynamic configuration
  - No more need to run zipl when kernel configuration changes

# Disk Partitioning

```
# fdasd -p /dev/dasda
```

```
...
```

```
reading volume label ..: VOL1
```

```
reading vtoc .....: ok
```

```
Disk /dev/dasda:
```

```
...
```

```
volume label .....: VOL1
```

```
volume serial .....: 0X0200
```

```
max partitions .....: 3
```

/boot/zipl

swap

System

----- tracks -----

Device	start	end	length	Id	System
/dev/dasda1	2	4267	4266	1	Linux native
/dev/dasda2	4268	9473	5206	2	Linux native
/dev/dasda3	9474	50084	40611	3	Linux native

```
· exiting...
```



# File Locations

- Multiple binaries are generated from the same source for consistency, then placed in different locations:
  - /boot/.image-3.12.28-4-default.hmac
  - /boot/System.map-3.12.28-4-default
  - /boot/config-3.12.28-4-default
  - /boot/image → /boot/image-3.12.28-4-default
  - /boot/initrd → /boot/initrd-3.12.28-4-default
  - /boot/initrd-3.12.28-4-default-kdump
  - /boot/vmlinuz-3.12.28-4-default
  - /lib/modules/3.12.28-4-default/ ...



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# Btrfs

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Why btrfs?

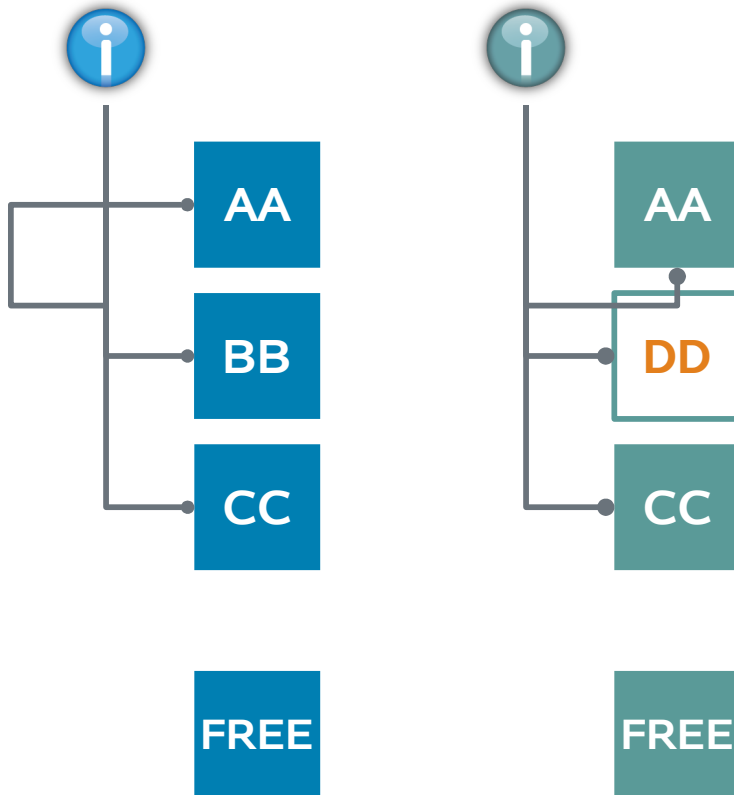
## **Btrfs (better fs) – Features**

- Scalability (16 EiB) including effective shrink
- Supports offline in-place migration from ext2, ext3
- Support for Copy on Write
- Powerful Snapshot capabilities
- Other Capabilities:
  - SSD optimization (TRIM support)
  - Data integrity (checksums)

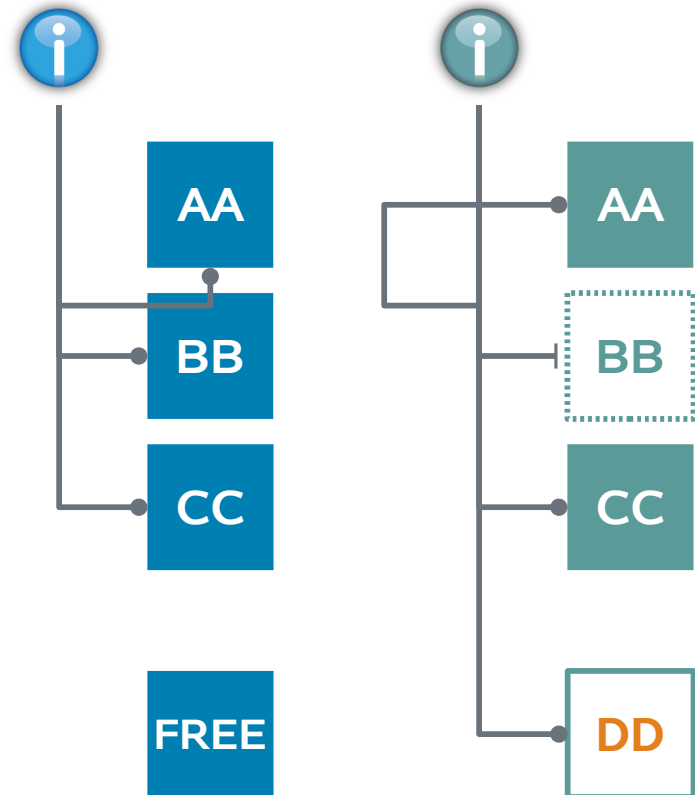
# Technology Overview

## Copy on Write

### “Normal” Write



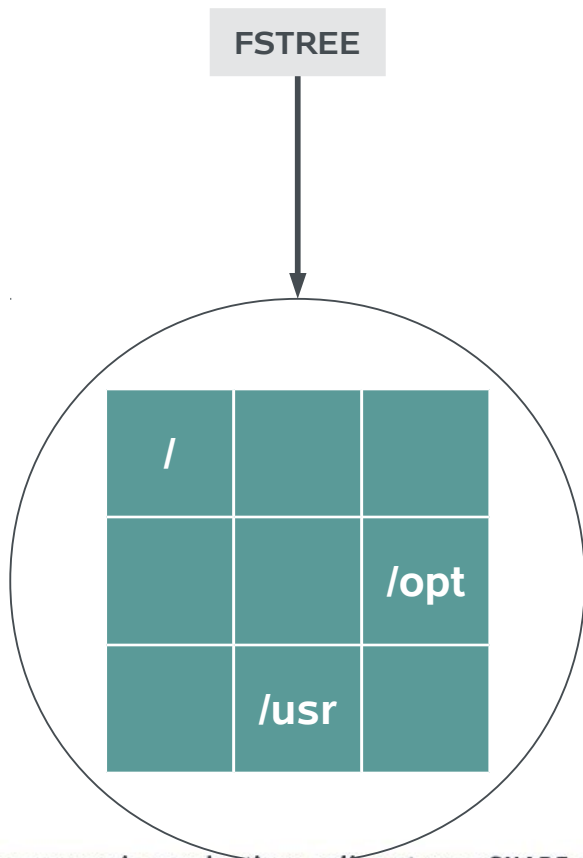
### Copy on Write



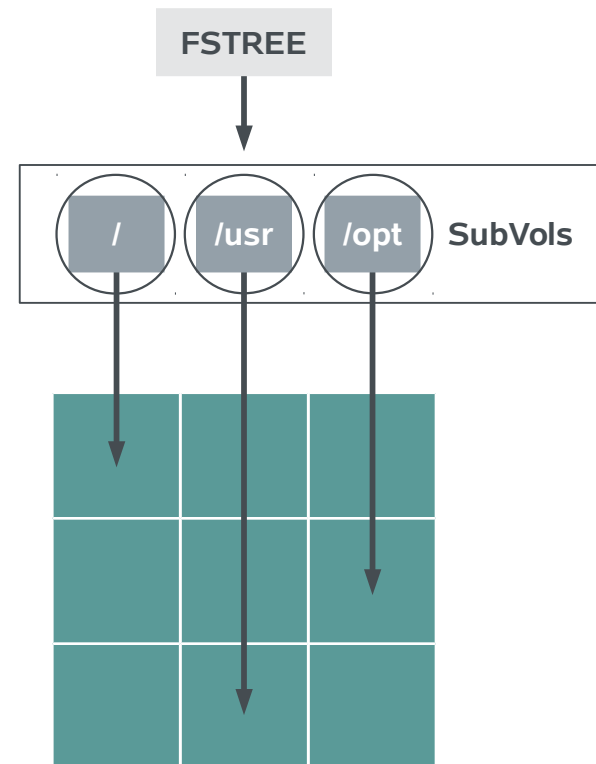
# Technology Overview

## Subvolume

### Normal Filesystem



### With Subvolumes



# Subvolume

- A complete filesystem tree
- Usually appears as a sub-directory in the “parent” fs
- Can be mounted separately
- not “just a subdirectory”
- Similiar to
  - two “foreign” filesystems, which are
  - using the same pool of data blocks (and other infrastructure)
- Benefits
  - different parts (subvolumes) of a filesystem can have different attributes, such as quotas or snapshotting rules
  - Copy on Write is possible across volumes
- Basic commandline management
  - “btrfs subvolume ...”



# Snapshots



- Copy on Write on a
  - full subvolume tree
  - instead of a single file only
- Every snapshot is again a subvolume of its own
- Snapshots (as subvolumes) can be mounted and accessed as every other subvolume
- Snapshots can be created read-only
- Basic commandline management
  - “btrfs subvolume snapshot ...”

# Requirements

- Single file rollback (“undochange”)
- Subvolume based rollback
- User interface: cmdline and YaST2 integration
- Snapshots for YaST2 and zypper activities
- Automated snapshots (time based)
- Automated snapshot cleanup (time/number based)
- Allow to work with several kernels



# Snapshotting “/” – Challenges

- Multiple Kernels
  - separate /boot
  - zypper integration
- System integrity and Compliance
  - Don't allow to roll back certain log-files etc.
  - Solution: subvolumes instead of directories for

/tmp

/opt

/srv

/var/spool

/var/log

/var/run

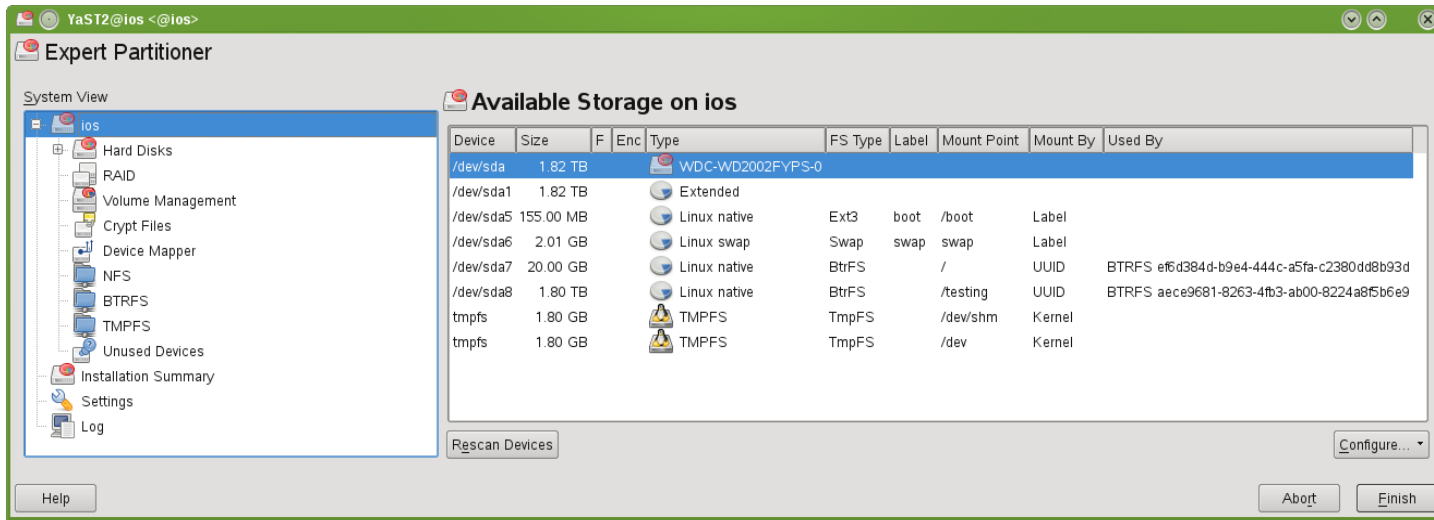
/var/tmp

# Snapshotting “/”



- We have decided to go the way of “/” in a subvolume
- Disadvantages of this model are mitigated by
  - support from the YaST2 Partitioner to install and configure
  - using “set-default” for the root filesystem to
    - make migration as smooth as possible
    - enable use of “normal” rescue systems

# Snapshotting “/” Partitions / Subvolumes



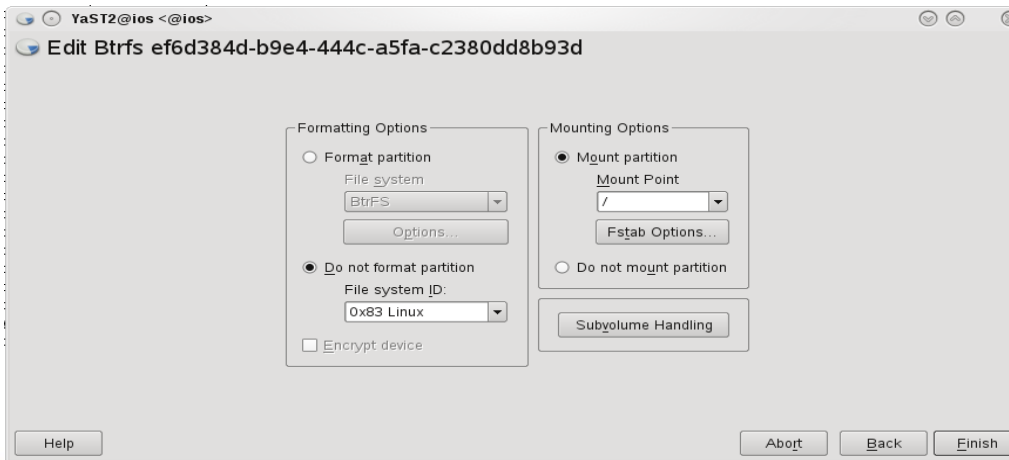
System View

- ios
  - Hard Disks
  - RAID
  - Volume Management
  - Crypt Files
  - Device Mapper
  - NFS
  - BTRFS
  - TMPFS
  - Unused Devices
  - Installation Summary
  - Settings
  - Log

Available Storage on ios

Device	Size	F	Enc	Type	FS Type	Label	Mount Point	Mount By	Used By
/dev/sda	1.82 TB			WDC-WD2002FYPS-0					
/dev/sda1	1.82 TB			Extended					
/dev/sda5	155.00 MB			Linux native	Ext3	boot	/boot	Label	
/dev/sda6	2.01 GB			Linux swap	Swap	swap	swap	Label	
/dev/sda7	20.00 GB			Linux native	BtrFS		/	UUID	BTRFS ef6d384d-b9e4-444c-a5fa-c2380dd8b93d
/dev/sda8	1.80 TB			Linux native	BtrFS		/testing	UUID	BTRFS aece9681-8263-4fb3-ab00-8224a8f5b6e9
tmpfs	1.80 GB			TMPFS	TmpFS		/dev/shm	Kernel	
tmpfs	1.80 GB			TMPFS	TmpFS		/dev	Kernel	

Buttons: Rescan Devices, Configure..., Abort, Finish, Help



Edit Btrfs ef6d384d-b9e4-444c-a5fa-c2380dd8b93d

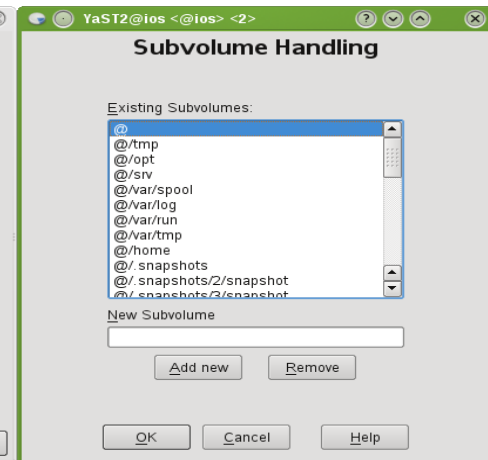
Formatting Options

- Format partition
  - File system: BtrFS
  - Options...
- Do not format partition
  - File system ID: 0x83 Linux
  - Encrypt device

Mounting Options

- Mount partition
  - Mount Point: /
  - Fstab Options...
- Do not mount partition

Buttons: Help, Abort, Back, Finish



Subvolume Handling

Existing Subvolumes:

- @
- @/tmp
- @/opt
- @/srv
- @/var/spool
- @/var/log
- @/var/run
- @/var/tmp
- @/home
- @/ snapshots
- @/ snapshots/2/snapshot
- @/ snapshots/3/snapshot

New Subvolume:

Buttons: Add new, Remove, OK, Cancel, Help

# snapper (1)

- cmdline tool to manage snapshots
- Commands
  - snapper list-configs
  - snapper create-config <subvolume>
  - snapper list
  - snapper create
  - snapper modify <number>
  - snapper delete <number>
  - snapper status <number1>..<number2>
  - snapper diff <number1>..<number2> [files]
  - snapper undochange <number1>..<number2> [files]
  - snapper cleanup <cleanup-algorithm>

# snapper (2)

- Configuration files:
  - /etc/snapper/configs/<per subvol>
  - /etc/sysconfig/snapper
- Time based snapshots
- Rules for deleting snapshots automatically

# snapper – example



2011-08-18 12:33 (0) ~

ios root (0) # snapper list

Type	#	Pre #	Date	Cleanup	Description
single	0				current
single	1		Wed 17 Aug 2011 04:30:01 PM CEST	timeline	timeline
pre	2		Wed 17 Aug 2011 04:31:54 PM CEST	number	yast lan
post	3	2	Wed 17 Aug 2011 04:32:46 PM CEST	number	
pre	4		Wed 17 Aug 2011 04:32:48 PM CEST	number	yast lan
post	5	4	Wed 17 Aug 2011 04:32:59 PM CEST	number	
pre	6		Wed 17 Aug 2011 04:36:10 PM CEST	number	zypp(zypper)
post	7	6	Wed 17 Aug 2011 04:36:11 PM CEST	number	
pre	8		Wed 17 Aug 2011 04:36:16 PM CEST	number	zypp(zypper)
post	9	8	Wed 17 Aug 2011 04:36:19 PM CEST	number	
pre	10		Wed 17 Aug 2011 04:36:26 PM CEST	number	yast printer
post	11	10	Wed 17 Aug 2011 04:37:21 PM CEST	number	
single	12		Wed 17 Aug 2011 05:30:01 PM CEST	timeline	timeline
single	13		Wed 17 Aug 2011 06:30:01 PM CEST	timeline	timeline
single	14		Wed 17 Aug 2011 07:30:01 PM CEST	timeline	timeline
single	15		Wed 17 Aug 2011 08:30:01 PM CEST	timeline	timeline
single	16		Wed 17 Aug 2011 09:30:01 PM CEST	timeline	timeline
single	17		Wed 17 Aug 2011 10:30:01 PM CEST	timeline	timeline
single	18		Wed 17 Aug 2011 11:30:01 PM CEST	timeline	timeline
single	19		Thu 18 Aug 2011 11:30:02 AM CEST	timeline	timeline
single	20		Thu 18 Aug 2011 12:30:01 PM CEST	timeline	timeline



# snapper – configuration



```
2011-08-18 13:45 (0) ~
ios root # cat
/etc/snapper/configs/root

# subvolume to snapshot
SUBVOLUME="/"

# filesystem type
FSTYPE="btrfs"

# run daily number cleanup
NUMBER_CLEANUP="yes"

# limit for number cleanup
NUMBER_MIN_AGE="1800"
NUMBER_LIMIT="100"

# create hourly snapshots
TIMELINE_CREATE="yes"

# ...
```

```
# ...

# cleanup hourly snapshots after some
time

TIMELINE_CLEANUP="yes"

# limits for timeline cleanup
TIMELINE_MIN_AGE="1800"
TIMELINE_LIMIT_HOURLY="10"
TIMELINE_LIMIT_DAILY="10"
TIMELINE_LIMIT_MONTHLY="10"
TIMELINE_LIMIT_YEARLY="10"

# cleanup empty pre-post-pairs
EMPTY_PRE_POST_CLEANUP="yes"

# limits for empty pre-post-pair
cleanup
EMPTY_PRE_POST_MIN_AGE="1800"
```

# ZYpp Integration

- ZYpp plugin for calling “snapper” on specific actions
- Uses “pairs” of snapshots:
  - one snapshot on ZYpp transaction start
  - one snapshot on ZYpp transaction stop
- Knowledge about pairs is stored in the snapshot metadata

```
2011-08-18 13:34 (0) ~
ios root (0) # cat /.snapshots/8/info.xml
<?xml version="1.0"?>
<snapshot>
  <type>pre</type>
  <num>8</num>
  <date>2011-08-17 14:36:16</date>
  <description>zypp( zypper )</description>
  <cleanup>number</cleanup>
</snapshot>
```

```
2011-08-18 13:34 (0) ~
ios root (0) # cat /.snapshots/9/info.xml
<?xml version="1.0"?>
<snapshot>
  <type>post</type>
  <num>9</num>
  <date>2011-08-17 14:36:19</date>
  <pre_num>8</pre_num>
  <cleanup>number</cleanup>
</snapshot>
```



# YaST2 integration

- Similar to ZYpp
- Snapshot-Pair with every start of a YaST module
- Description covers the name of the module

```
2011-08-18 13:32 (0) ~
ios root (0) # cat /.snapshots/10/info.xml
<?xml version="1.0"?>
<snapshot>
  <type>pre</type>
  <num>10</num>
  <date>2011-08-17 14:36:26</date>
  <description>yast printer</description>
  <cleanup>number</cleanup>
</snapshot>
```

```
2011-08-18 13:32 (0) ~
ios root (0) # cat /.snapshots/11/info.xml
<?xml version="1.0"?>
<snapshot>
  <type>post</type>
  <num>11</num>
  <date>2011-08-17 14:37:21</date>
  <pre_num>10</pre_num>
  <cleanup>number</cleanup>
</snapshot>
```



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# Demo

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```
x3270-4 zvm54.suse.de
File Options
GNU GRUB version 2.02~beta2

Use the ^ and v keys to select which entry is highlighted. Press
enter to boot the selected OS, `e' to edit the commands before
booting or `c' for a command-line.

*(1) SLES12
(2) Advanced options for SLES12
(s) Start bootloader from a read-only snapshot

The highlighted entry will be executed automatically in 8s. 7s 6s 5s 4s1

Loading Linux 3.12.28-4-default ...
Loading initial ramdisk ...
Performing 'kexec -l /boot/image-3.12.28-4-default
--initrd=/boot/initrd-3.12.28-4-default
--command-line=root=UUID=3992bb27-af79-4908-a541-df8d7c5e95fd
hvc_iucv=8 TERM=dumb resume=/dev/disk/by-path/ccw-0.0.0200-part2
cio_ignore=all,!ipldev,!condev'
Performing 'systemctl kexec' (just-in-case) Performing 'kexec -e'Initializing c
group subsys cpuset
Initializing cgroup subsys cpu
Initializing cgroup subsys cpuacct
Linux version 3.12.28-4-default (geeko@buildhost) (gcc version 4.8.3 20140627 [g
cc-4_8-branch revision 212064] (SUSE Linux) ) #1 SMP Thu Sep 25 17:02:34 UTC 201
4 (9879bd4)
setup.1a06a7: Linux is running as a z/VM guest operating system in 64-bit mode
Zone ranges:
DMA [mem 0x00000000-0x7fffffff]
Normal empty
```



```
x3270-4 zvm54.suse.de
File Options
enter to boot the selected OS, `e` to edit the commands before
booting or `c` for a command-line.

*(1) SLES12
(2) Advanced options for SLES12
(s) Start bootloader from a read-only snapshot

The highlighted entry will be executed automatically in 8s. 7s 6s 5s 4ss

GNU GRUB version 2.02~beta2

Use the ^ and v keys to select which entry is highlighted. Press
enter to boot the selected OS, `e` to edit the commands before
booting or `c` for a command-line. ESC to return previous menu.

*(1) SLES 12 (3.12.28-4,2015-03-03T23:30,timeline)
(2) SLES 12 (3.12.28-4,2015-03-03T22:30,timeline)
(3) SLES 12 (3.12.28-4,2015-03-03T18:30,timeline)
(4) SLES 12 (3.12.28-4,2015-03-02T19:30,timeline)
(5) SLES 12 (3.12.28-4,2015-03-02T18:58,post)
(6) SLES 12 (3.12.28-4,2015-03-02T18:58,pre,zypp(zypper))
(7) SLES 12 (3.12.28-4,2015-03-02T18:50)
(8) SLES 12 (3.12.28-4,2015-03-02T18:49,post)
(9) SLES 12 (3.12.28-4,2015-03-02T18:49,pre,zypp(zypper))
```



# IPL / Boot Snapshot 0



```
x3270-4 zvm54.suse.de
File Options
s390vsw176:~ # snapper list
snapper list
Type | # | Pre # | Date | User | Cleanup | Description | Userdata
-----+-----+-----+-----+-----+-----+-----+-----
single | 0 | | | root | | current |
s390vsw176:~ #
```



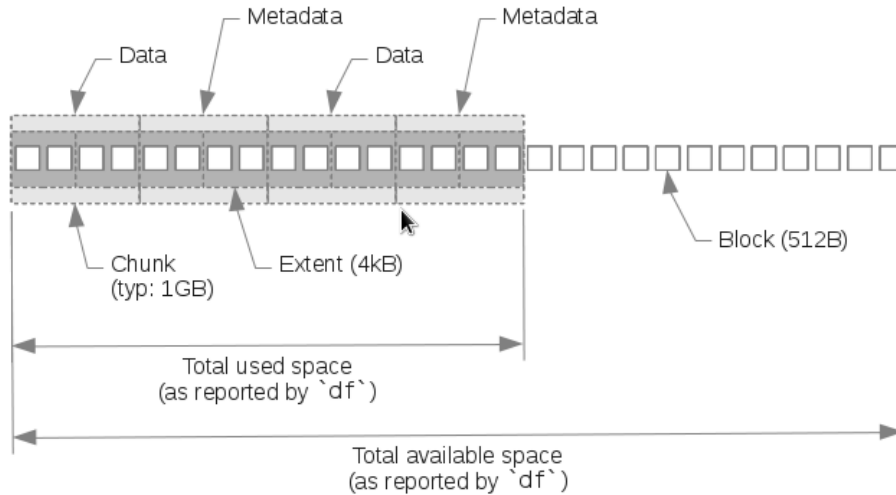
# IPL / Boot Snapshot 9



```
x3270-4 zvm54.suse.de
File Options
s390vsw176:~ # snapper list
snapper list
Type | # | Pre # | Date | User | Cleanup | Description | Userdata
-----+-----+-----+-----+-----+-----+-----+-----
single | 0 | | | root | | current |
pre | 1 | | Mon Mar 2 19:49:30 2015 | root | number | zypp(zypper) | important=no
post | 2 | 1 | Mon Mar 2 19:49:31 2015 | root | number | | important=no
single | 3 | | Mon Mar 2 19:50:12 2015 | root | | |
pre | 4 | | Mon Mar 2 19:58:35 2015 | root | number | zypp(zypper) | important=no
post | 5 | 4 | Mon Mar 2 19:58:42 2015 | root | number | | important=no
single | 6 | | Mon Mar 2 20:30:02 2015 | root | timeline | timeline |
single | 7 | | Tue Mar 3 19:30:02 2015 | root | timeline | timeline |
single | 8 | | Tue Mar 3 23:30:01 2015 | root | timeline | timeline |
single | 9 | | Wed Mar 4 00:30:01 2015 | root | timeline | timeline |
s390vsw176:~ #
```



# Btrfs Disk Space And Extents



In case of a Btrfs filesystem on a single underlying block device

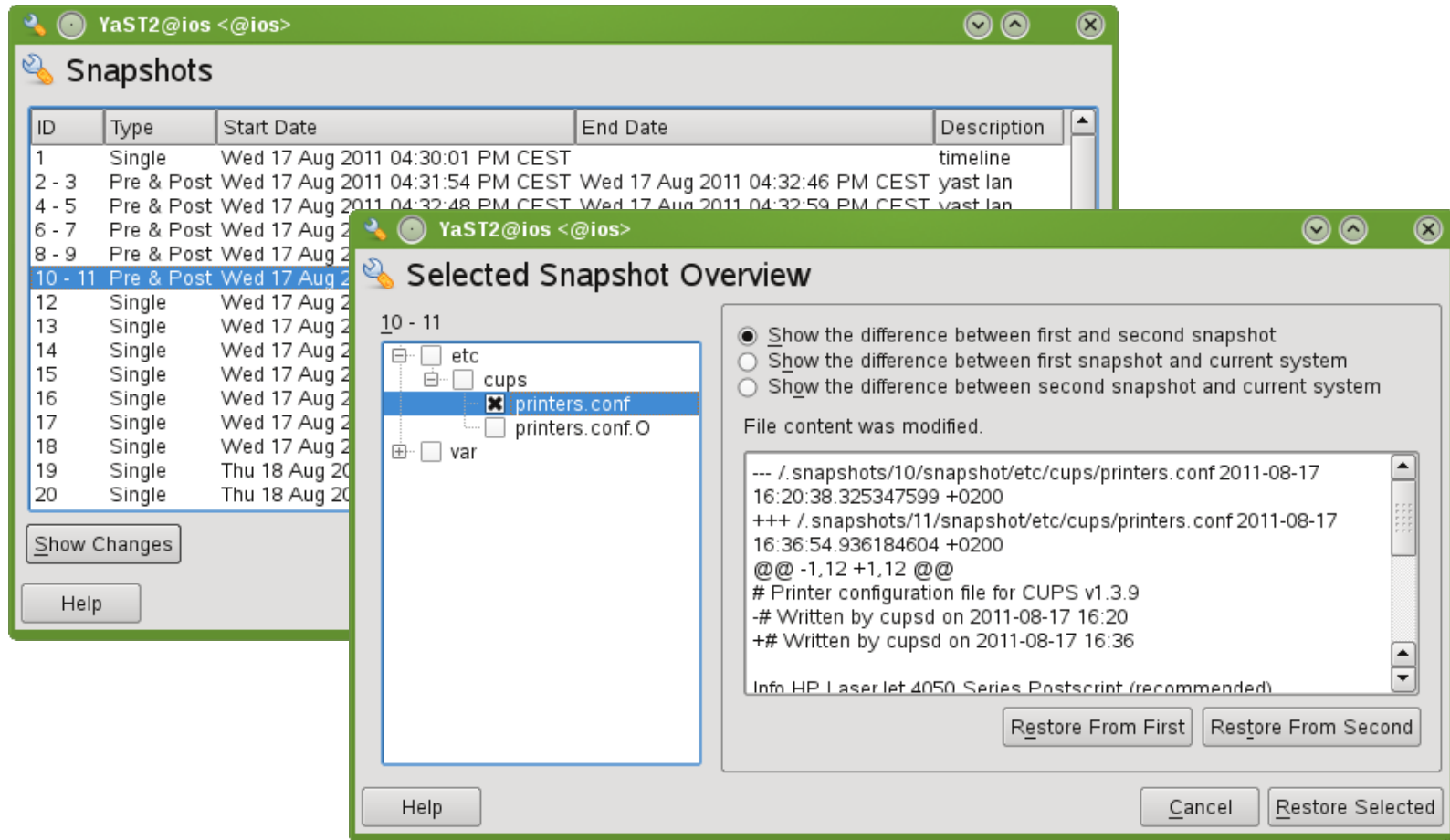
```
# btrfs filesystem df /
Data: total=14.50GB, used=12.20GB
System, DUP: total=8.00MB, used=12.00KB
System: total=4.00MB, used=0.00
Metadata, DUP: total=1.75GB, used=904.11MB
```

```
# df -h /
Filesystem      Size  Used Avail Use% Mounted on
/dev/sda7       20G   14G   4.3G  77% /
#
```

## Disk utilization

12,2GB + 2x 0,9GB + = 14 GB

# Managing Difference With YaST2



The image shows two windows from the YaST2 application. The background window is titled "Snapshots" and displays a table of snapshot records. The foreground window is titled "Selected Snapshot Overview" and shows a file tree with "printers.conf" selected, along with radio buttons for comparison options and a diff view of the file's content.

**Snapshots Table:**

ID	Type	Start Date	End Date	Description
1	Single	Wed 17 Aug 2011 04:30:01 PM CEST		timeline
2 - 3	Pre & Post	Wed 17 Aug 2011 04:31:54 PM CEST	Wed 17 Aug 2011 04:32:46 PM CEST	yast lan
4 - 5	Pre & Post	Wed 17 Aug 2011 04:32:48 PM CEST	Wed 17 Aug 2011 04:32:59 PM CEST	yast lan
6 - 7	Pre & Post	Wed 17 Aug 2011 04:32:59 PM CEST		
8 - 9	Pre & Post	Wed 17 Aug 2011 04:32:59 PM CEST		
10 - 11	Pre & Post	Wed 17 Aug 2011 04:32:59 PM CEST		
12	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
13	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
14	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
15	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
16	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
17	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
18	Single	Wed 17 Aug 2011 04:32:59 PM CEST		
19	Single	Thu 18 Aug 2011 04:32:59 PM CEST		
20	Single	Thu 18 Aug 2011 04:32:59 PM CEST		

**Selected Snapshot Overview Dialog:**

- Show the difference between first and second snapshot
- Show the difference between first snapshot and current system
- Show the difference between second snapshot and current system

File content was modified.

```
--- /.snapshots/10/snapshot/etc/cups/printers.conf 2011-08-17 16:20:38.325347599 +0200
+++ /.snapshots/11/snapshot/etc/cups/printers.conf 2011-08-17 16:36:54.936184604 +0200
@@ -1,12 +1,12 @@
# Printer configuration file for CUPS v1.3.9
-# Written by cupsd on 2011-08-17 16:20
+# Written by cupsd on 2011-08-17 16:36

Info HP LaserJet 4050 Series Postscript (recommended)
```

Buttons: Restore From First, Restore From Second, Cancel, Restore Selected



# Session 16432



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# Snapshotting “/” – “/” in a subvolume

- “/” filesystem is in a separate subvolume,
  - mounted as “/” during boot
  - Based on a proposal by the Debian community,
  - this root-subvolume is named “@”
  - Namespace: all Subvolumes starting with “@” are mounted below “@/” automatically
- Benefits
  - Flexible and Future proof
  - subvolume based rollback relatively easy to implement, as all volumes are subvolumes already
- Disadvantage
  - Some learning for people coming from the traditional filesystems
  - “set-default” is necessary to avoid complexity in a first step

# napshotting “/” – Traditional Method



- “/” filesystem is mounted as any other Linux filesystem: root volume of the btrfs filesystem = “/” in a user's view
- Benefits
  - No difference for people coming from ext3, xfs, ...
  - no “set-default” necessary
- Disadvantages
  - subvolume based rollback introduces additional complexity
  - less flexibility for future improvements,
    - e.g. no “parallel root filesystems”



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# cgroups - Resource Control

Consider a large university server with various users - students, professors, system tasks etc. The resource planning for this server could be along the following lines:

## CPU

Top cpuset (20%)	
/	\
CPUSet1	CPUSet2
(Profs)	(Students)
60%	20%

## Memory

Professors = 50%  
 Students = 30%  
 System = 20%

## Disk I/O

Professors = 50%  
 Students = 30%  
 System = 20%

## Network I/O

WWW browsing = 20%

/	\
Prof (15%)	Students (5%)

Network File System (60%)

Others (20%)

Improve Operational Efficiency

# Systemd: System/Service Manager



- Init Replacement
  - Bring up system and start services
  - Integrate system wide ulimit settings and Cgroups
  - Activation via Socket and d-bus
- Command line “systemctl”
  - Compatibility with SystemV init scripts
  - Provide infrastructure for existing ISV applications
  - LSB compatibility
- SUSE specific usability enhancements
  - Keep insserv, chkconfig and /sbin/service
  - Old style (calling “rc...”) redirected to systemctl
  - LSB compatibility for targets like \$network...

# Lots Of Mounted Filesystems

- # mount
- sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
- proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
- devtmpfs on /dev type devtmpfs (rw,nosuid,size=244032k,nr\_inodes=61008,mode=755)
- securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)
- tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
- devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
- tmpfs on /run type tmpfs (rw,nosuid,nodev,mode=755)
- tmpfs on /sys/fs/cgroup type tmpfs (rw,nosuid,nodev,noexec,mode=755)
- cgroup on /sys/fs/cgroup/systemd type cgroup (rw,nosuid,nodev,noexec,relatime,xattr,release\_agent=/usr/lib/systemd/systemd-cgroups-agent,name=systemd)
- pstore on /sys/fs/pstore type pstore (rw,nosuid,nodev,noexec,relatime)
- cgroup on /sys/fs/cgroup/cpuset type cgroup (rw,nosuid,nodev,noexec,relatime,cpuset)
- cgroup on /sys/fs/cgroup/cpu,cpuacct type cgroup (rw,nosuid,nodev,noexec,relatime,cpuacct,cpu)
- cgroup on /sys/fs/cgroup/memory type cgroup (rw,nosuid,nodev,noexec,relatime,memory)
- cgroup on /sys/fs/cgroup/devices type cgroup (rw,nosuid,nodev,noexec,relatime,devices)
- cgroup on /sys/fs/cgroup/freezer type cgroup (rw,nosuid,nodev,noexec,relatime,freezer)
- cgroup on /sys/fs/cgroup/bkpio type cgroup (rw,nosuid,nodev,noexec,relatime,bkpio)
- cgroup on /sys/fs/cgroup/perf\_event type cgroup (rw,nosuid,nodev,noexec,relatime,perf\_event)
- cgroup on /sys/fs/cgroup/hugetlb type cgroup (rw,nosuid,nodev,noexec,relatime,hugetlb)
- /dev/dasda3 on / type btrfs (rw,relatime,space\_cache)
- systemd-1 on /proc/sys/fs/binfmt\_misc type autofs (rw,relatime,fd=28,pgrp=1,timeout=300,minproto=5,maxproto=5,direct)
- debugfs on /sys/kernel/debug type debugfs (rw,relatime)
- mqueue on /dev/mqueue type mqueue (rw,relatime)
- hugetlbfs on /dev/hugepages type hugetlbfs (rw,relatime)
- /dev/dasda3 on /var/tmp type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /var/spool type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /var/opt type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /var/log type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /var/lib/postgresql type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /var/lib/named type btrfs (rw,relatime,space\_cache)
- /dev/dasda1 on /boot/zipl type ext2 (rw,relatime)
- /dev/dasda3 on /var/lib/mailman type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /usr/local type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /tmp type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /var/crash type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /srv type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /opt type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /home type btrfs (rw,relatime,space\_cache)
- /dev/dasda3 on /boot/grub2/s390x-emu type btrfs (rw,relatime,space\_cache)



# Lots Of Mounted Filesystems

- # mount
- sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
- proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
- devtmpfs on /dev type devtmpfs (rw,nosuid,size=244032k,nr\_inodes=61008,mode=755)
- securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)
- tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
- devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
- tmpfs on /run type tmpfs (rw,nosuid,nodev,mode=755)
- tmpfs on /sys/fs/cgroup type tmpfs (rw,nosuid,nodev,noexec,mode=755)
- cgroup on /sys/fs/cgroup/systemd type cgroup (rw,nosuid,nodev,noexec,relatime,xattr,release\_agent=/usr/lib/systemd/systemd-cgroups-agent,name=systemd)
- pstore on /sys/fs/pstore type pstore (rw,nosuid,nodev,noexec,relatime)
- cgroup on /sys/fs/cgroup/cpuset type cgroup (rw,nosuid,nodev,noexec,relatime,cpuset)
- cgroup on /sys/fs/cgroup/cpu,cpuacct type cgroup (rw,nosuid,nodev,noexec,relatime,cpuacct,cpu)
- cgroup on /sys/fs/cgroup/memory type cgroup (rw,nosuid,nodev,noexec,relatime,memory)
- cgroup on /sys/fs/cgroup/devices type cgroup (rw,nosuid,nodev,noexec,relatime,devices)
- cgroup on /sys/fs/cgroup/freezer type cgroup (rw,nosuid,nodev,noexec,relatime,freezer)
- cgroup on /sys/fs/cgroup/blkio type cgroup (rw,nosuid,nodev,noexec,relatime,blkio)
- cgroup on /sys/fs/cgroup/perf\_event type cgroup (rw,nosuid,nodev,noexec,relatime,perf\_event)
- cgroup on /sys/fs/cgroup/hugetlb type cgroup (rw,nosuid,nodev,noexec,relatime,hugetlb)

# Lots Of Mounted Filesystems

- # mount

systemd-1 on /proc/sys/fs/binfmt\_misc type autofs  
(rw,relatime,fd=28,pgrp=1,timeout=300,minproto=5,maxproto=5,direct)

debugfs on /sys/kernel/debug type debugfs (rw,relatime)

mqueue on /dev/mqueue type mqueue (rw,relatime)

hugetlbfs on /dev/hugepages type hugetlbfs (rw,relatime)

# Lots Of Mounted Filesystems

```
# mount
```

```
/dev/dasda1 on /boot/zipl type ext2 (rw,relatime)
```

```
/dev/dasda3 on /boot/grub2/s390x-emu type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on / type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/tmp type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/spool type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/opt type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/log type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/lib/pgsql type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/lib/named type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/lib/mailman type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /var/crash type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /usr/local type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /tmp type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /srv type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /opt type btrfs (rw,relatime,space_cache)
```

```
/dev/dasda3 on /home type btrfs (rw,relatime,space_cache)
```

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