Performance evaluation of Linux Discard Support

(Overview, benchmark results, current status)

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May 27, 2011

Part I

Discard Background

Agenda

Solid-State Drive

- Flash memory block device
- Wear-leveling needed
- Firmware = black box

ATA TRIM Command

- Helps handle garbage collection overhead
- Subsequent READ of TRIM'ed blocks
  1. Read data should NOT change between READ's
  2. Read data should NOT be retrieved from data previously written to any other LBA.
- As long as the device has enough free pages to write to we do not necessarily need it.
- In a nutshell: TRIM command tells the device what LBA'a is not used by the OS anymore.

Thin Provisioning

- Unlike in traditional storage, there is no fixed one-to-one logical bock to physical storage mapping
- More efficient use of storage space
- Block reclamation interface needed

SCSI UNMAP / WRITE SAME

- Storage space reclamation interface
- Subsequent READ of unmapped blocks
  1. Read data should NOT change between READ's
  2. Read data should NOT be retrieved from data previously written to any other LBA.
- Unlike with SSD's we can not afford to wait until we run out of space for reclamation.

Linux Discard Implementation

- Abstraction for the two underlying specifications:
  1. ATA TRIM Command
  2. SCSI UNMAP / WRITE SAME
- API for user-space
  - BLKDISCARD ioctl
  - Added with v2.6.27-rc9-30-gd30a260
- API for File Sytems
  1. `sb_issue_discard()`
  2. `blkdev_issue_discard()`

Part II

Discard Performance

Agenda

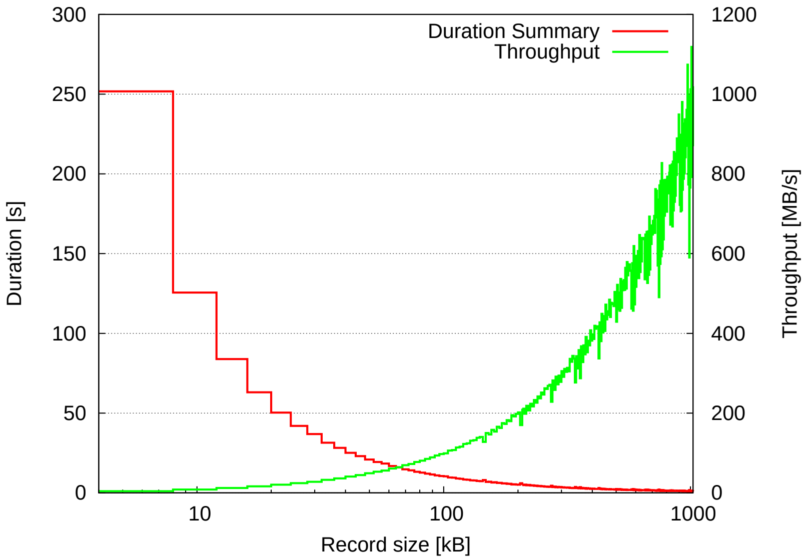
What do we need to find out ?

- Does discard really work ? Is it reliable ?
- How fast/slow is it ?
- Is there any difference between devices from different vendors ?
- What is the ideal discard size ?
- SSD performance degradation

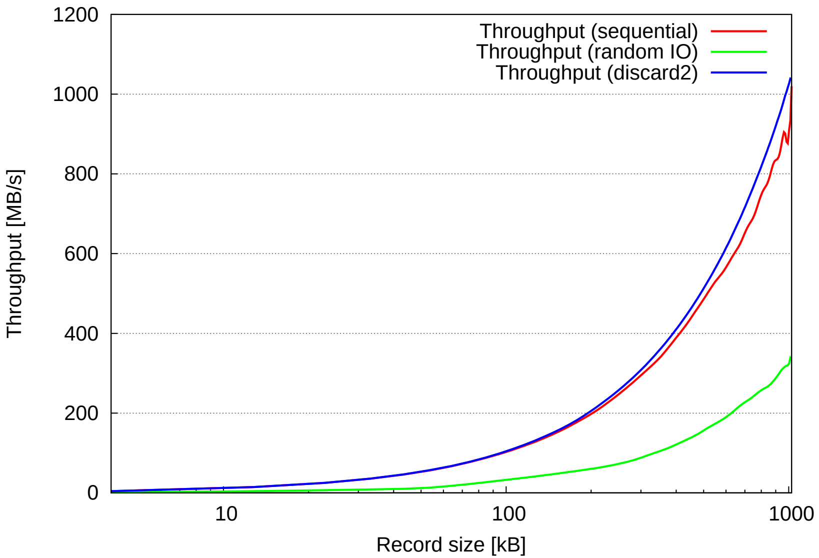
How do we test it ?

- BLKDISCARD ioctl()
- Automatic discard of different ranges
- Different discard patterns
  1. sequential performance
  2. random IO peformance
  3. discard already discarded blocks
- test-discard - discard benchmarking tool
  - http://sourceforge.net/projects/test-discard/
- impression - filesystem aging tool

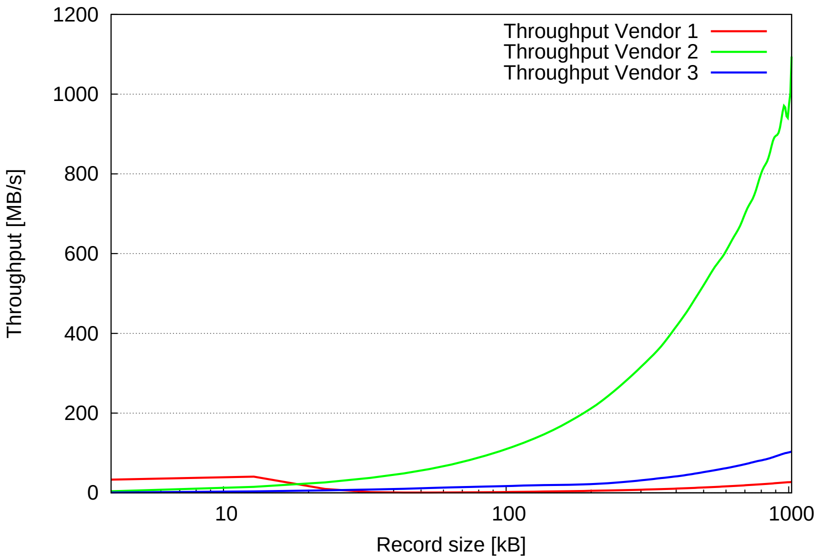
Sequential discard performance



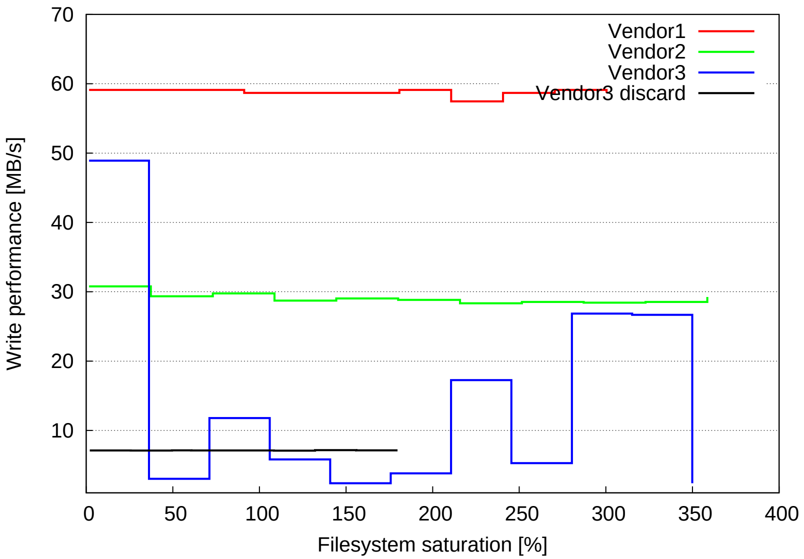
Different modes comparison



Difference between various vendors



SSD performance degradation



Part III
Discard Support for Linux File systems

Agenda

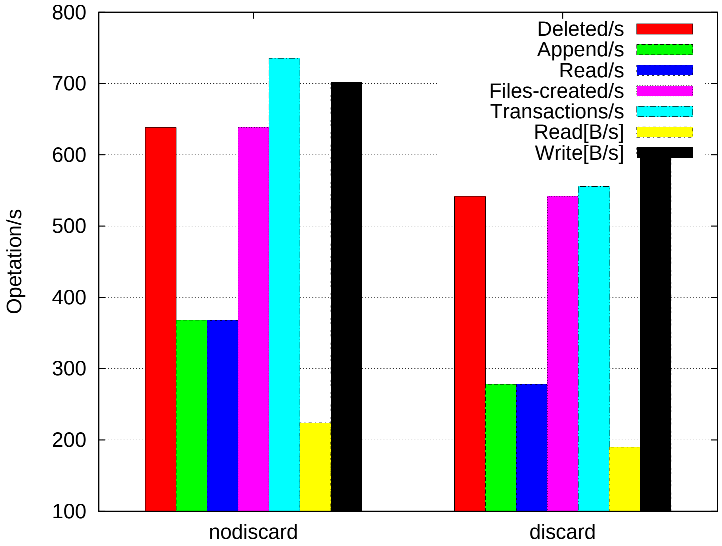
Periodic discard

- Easy to implement
- File system support
  1. ext4 (v2.6.27-5185-g8a0aba7)
  2. btrfs (since upstream)
  3. gfs2 (v2.6.29-9-gf15ab56)
  4. fat, swap, nilfs
- `mount -o discard /dev/sdc /mnt/test`
- TRIM is non-queueable command - implications ?

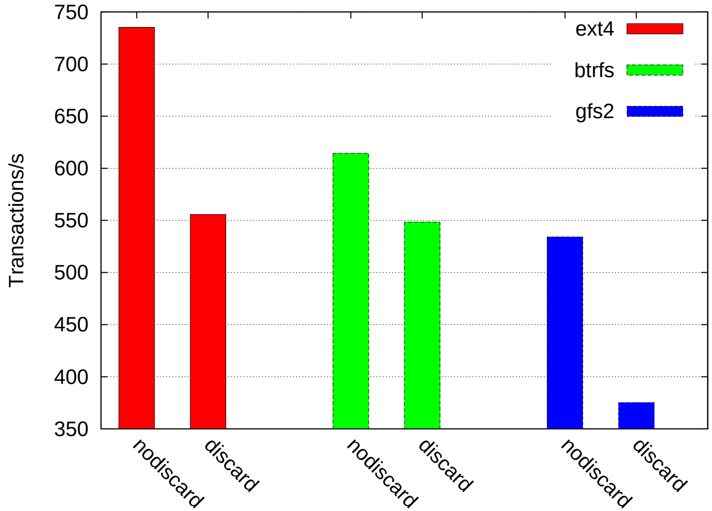
Benchmarking periodic discard

- Expectations ?
- Testing methodology
  1. Metadata intensive load
  2. Load with removing files
  3. Reasonable file size distribution
- Discard-kit
  1. Using PostMark
  2. http://sourceforge.net/projects/test-discard/files/

Ext4 performance (18% hit)



Performance with various file systems



-18% -7% -63%

Discard Batching - The idea

- Fine-grained discard is not necessarily needed
- Small extents are slow
- With time, freed extents tends to coalesce
- Disadvantages
  1. There is a price for tracking freed extents
  2. Discarding already discarded blocks should be easy, but...
  3. Daemon (in-kernel, user-space) needed.
  4. File system independent solution would most likely be pain to do right (if possible).

Batched discard support

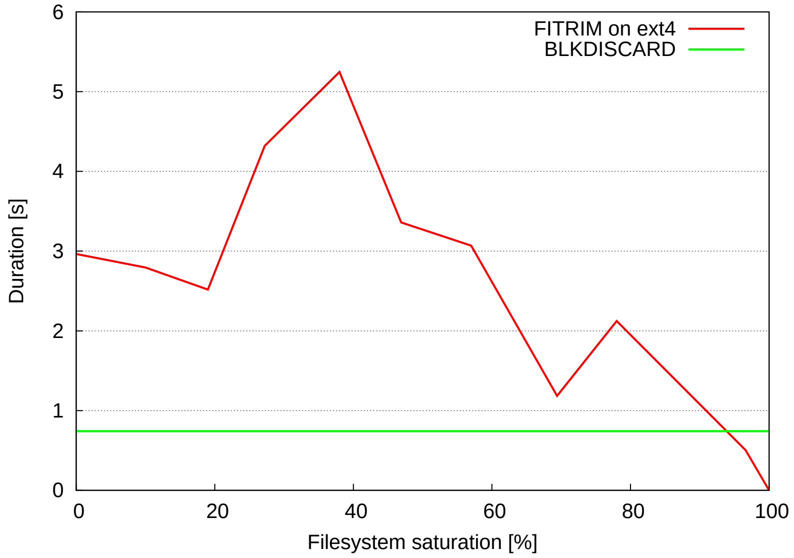
- File system specific solution
- Provide ioctl() interface - FITRIM
- Do not disturb other ongoing IO too much
  1. Prevent allocations while trimming
  2. How to handle huge filesystem ?
- File system support
  1. ext4 (v2.6.36-rc6-35-g7360d17)
  2. ext3 (v2.6.37-11-g9c52749)
  3. xfs (v2.6.37-rc4-63-ga46db60)

FITRIM ioctl

- Ioctl with one RW parameter defined in `linux/fs.h`

  ```
  struct fstrim_range {
  __u64 start;
  __u64 len;
  __u64 minlen;
  }
  ```
- fstrim tool
  - http://sourceforge.net/projects/fstrim/
- util-linux-ng
  - Since v2.18-165-gd9e2d0d

Batched discard benchmark results



Alternative approach

- It is always a compromise
- The future of SSD's and thinly provisioned LUN's (???)

Part IV

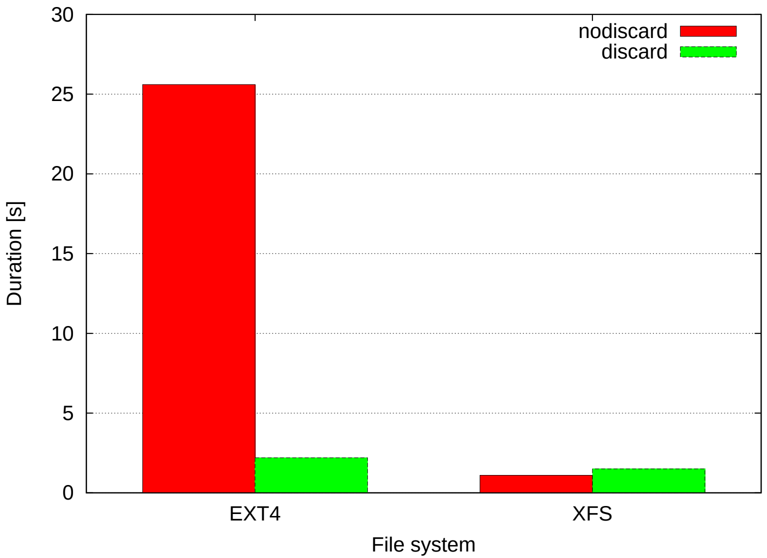
Discard Support in user-space

Agenda

Discard in e2fsprogs tools

- Using BLKDISCARD ioctl()
- mke2fs
  1. Refresh SSD's garbage collector
  2. discard zeroes data - significant speed boost
  3. `mkfs.ext4 -E discard /dev/sdc`
- e2fsck
  1. After the last check discard free space
  2. Non detected file system errors ? oops
  3. `fsck.ext4 -E discard /dev/sdc`
- resize2fs
  1. Refresh SSD's garbage collector
  2. discard zeroes data - significant speed boost
  3. `resize2fs -E discard /dev/sdc`

File system creation



Fstrim tool

- Very simple tool to invoke FITRIM ioctl on mounted file system
- Stand-alone tool
  - http://sourceforge.net/projects/fstrim/
- Since v2.18-165-gd9e2d0d part of util-linux-ng

Part V

Summary

Summary

- Linux Discard support is a abstraction for underlying specification
- Exported via BLKDISCARD ioctl to user-space and blkdev_issue_discard() for filesystems
- Discard testing kit (Discard-kit)
  1. test-discard
  2. PostMark
- Filesystem support
  1. Fine grained (online) discard - `mount -o discard`
  2. Batched discard support - fstrim from util-linux-ng
- Support in user-space utilities
  1. Filesystem creation (mkfs)
  2. e2fsprogs - mkfs,e2fsck,resize2fs
  3. xfsprogs - mkfs
  4. fstrim

The end.

Thanks for listening.

Useful links

- http://sourceforge.net/projects/fstrim/
- http://sourceforge.net/projects/test-discard/
- http://people.redhat.com/lczerner/discard/