

# Partition Alignment of Intel<sup>®</sup> SSDs for Achieving Maximum Performance and Endurance

Technical Brief  
*February 2014*

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## Revision History

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Document Number	Revision Number	Description	Revision Date
330105	001	<ul style="list-style-type: none"><li>Initial release.</li></ul>	February 2014



# 1 Introduction

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## 1.1 About This Guide

This guide provides a technical overview of partition alignment on an individual Intel® Solid-State Drive (SSD).

The audience is any user of Intel SSDs, specifically Enterprise level System Administrators and Engineers.

There is a great deal of information on the internet regarding partition alignment on SSDs. This brief will attempt to address some of that information and explain the importance of alignment on Intel SSDs in order to achieve maximum performance and longest life from a drive. Misalignment can negatively impact the performance of Intel's Consistently Amazing Data Center Family of SSDs. This brief will describe the procedures for checking the alignment of partitions under the Windows Operating System (OS) and the Linux\* family of OS's. It will also explain the procedure to re-align a partition using standard tools. By following these steps, an SSD can attain the speed, endurance, and consistency of performance it was designed to produce.

## 1.2 Anatomy of a Drive

In traditional Hard Disk Drives (HDDs), a 512 Byte physical sector size has been the standard. Operating systems understand this sector layout and align their partitions with these sectors. However, most new HDDs use a 4096 Byte physical sector size, which is translated by the firmware to mimic a 512 Byte sector size to the Operating System (OS). Intel SSDs also have physical structures, similar to sectors, called pages. Intel SSDs have different page sizes depending on the model, but the current Intel Datacenter SSDs have 8 KB and 16KB pages. These pages are then organized into blocks. On top of these structures is an abstraction layer that makes the SSD appear to the OS as a traditional HDD. But, it is the internal structure that makes alignment so important.

## 2 Why Alignment is Important

### 2.1 Partition Offset

Windows\* up to and including Server 2003\* uses a first partition offset of 63 sectors to comply with the 63 hidden sectors reported by disk hardware. Assuming 512 Byte sectors gives an offset equal to 31.5KB. This works fine on traditional 512B sector HDDs, but does not work well for Intel SSDs due to misalignment. It is possible to manually align the partition offset to 64 sectors, or 32 KB. This configuration is better than the misalignment caused by 63 sectors, but is not recommended for Windows\* servers. Windows\* Server 2008 and newer use an offset of 1024KB (1 MB), which is the recommended offset for Intel SSDs. Partitioning tools in Linux, such as GPARTED, also use an offset of 1 MB in newer versions.

### 2.2 File System

The default file system for Windows\* Server 2003, NTFS, uses 4 KB clusters by default. Traditionally, these 4KB clusters take up 8 – 512 Byte sectors. With Intel SSDs, 1 - NTFS cluster takes up less than one NAND page when alignment is correct. When the alignment is not correct, some of the 4 KB clusters will write across 2 NAND pages. This is illustrated in Figure 1 using 4 KB pages for clarity: With an offset of 63 sectors, the first 31.5 KB of drive space is left blank. Then Windows\* begins to write clusters, but the physical page of the SSD ends at 32 KB. Therefore, the cluster is split across 2 pages: 512 Bytes written on the first, 3.5 KB written on the next. This has a cumulative effect as each subsequent page boundary that is written will have a cluster split across it. Figure 2–1 shows a misaligned partition, figure 2–2 shows a partition properly aligned at 1MB.

Figure 2-1: Misaligned Partition

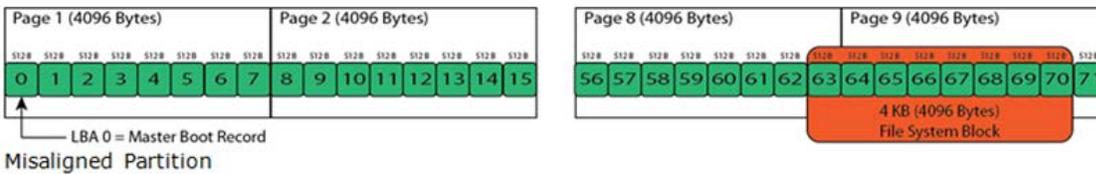
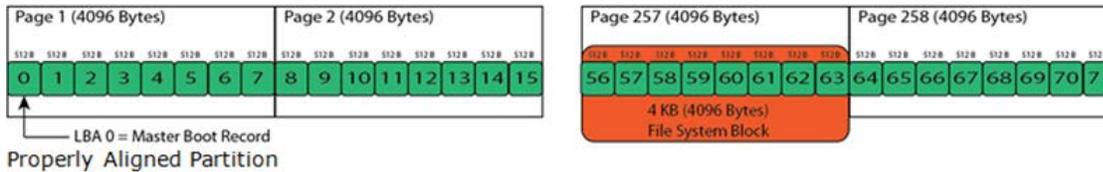
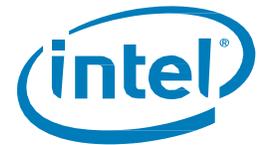


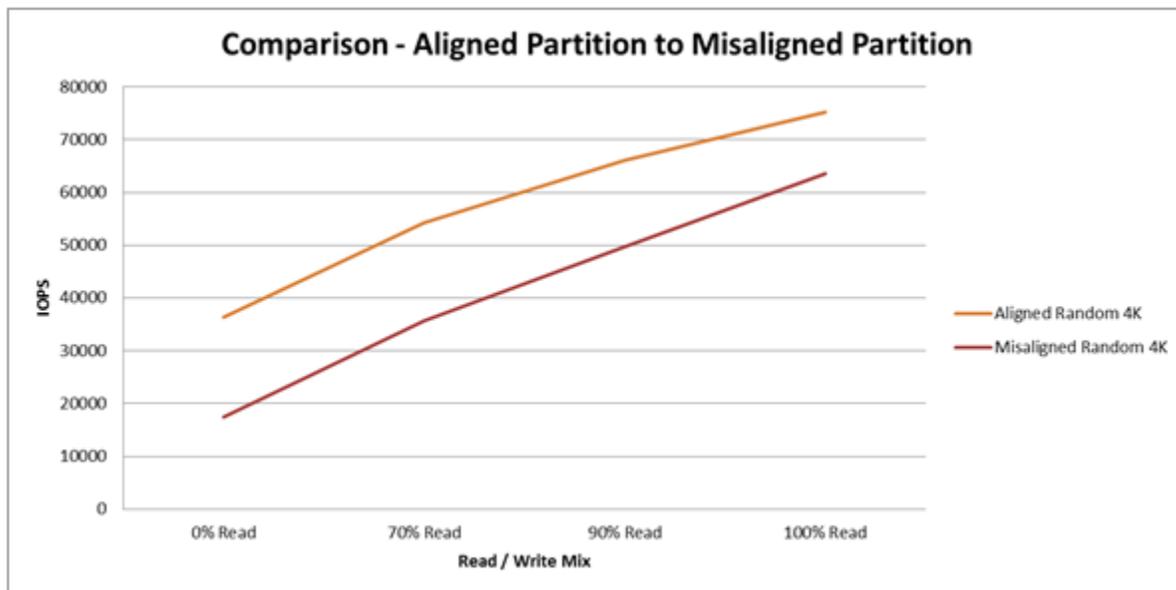
Figure 2-2: Properly Aligned Partition at 1MB





The most noticeable problem caused by misalignment is poor performance. Because the drive has to write two pages (two separate writes) for any OS cluster write that crosses a page boundary, additional latency is introduced causing slower write speeds. Figure 2–3 shows a comparison of the performance of an aligned partition compared to the performance of a misaligned partition.

**Figure 2-3: Performance Comparison, Aligned Partition versus Misaligned Partition**





## 3 Proper File System Alignment

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There are a few different ways to check your partition alignment, depending on the OS being used. Two common examples are presented here.

### 3.1 Checking Alignment

Windows\* OS using msinfo32.exe:

- Hit the START button and type msinfo32.exe
- Navigate to *Components > Storage > Disks*
- Identify and select the appropriate drive
- Locate *Partition Starting Offset*
- Divide the offset number by 4096
- If the result is a whole number (no decimal), the partition is correctly aligned
- Repeat for each partition

Linux\* OS:

- Run *parted*
- Enter *unit s*
- Enter *print all*
- Each disk will be listed with its partitions, showing start points and end points in sectors
- The heading for each drive should show Sector size (logical/physical): 512B/512B
- Multiply the Start number by the Units number i.e.  $63 * 512 = 32256$
- Divide the result by 4096: such as  $32256 / 4096 = 7.875$
- If the result is NOT a whole number (as shown above), the partition is NOT aligned on a 4KB boundary
- Repeat this process for each partition listed

### 3.2 Alignment for Windows

If a partition is misaligned in Windows\* Server 2003 or older, there are some considerations to understand before attempting to repair it. If the drive containing the misaligned partition is running the Windows\* OS (even if Windows\* is not on the misaligned **partition**), moving the partition from within Windows\* is not an option. In this type case, the OS must be de-installed, the partitions aligned, then the OS must be reinstalled. Windows\* Server 2008 and newer can move partitions within *Computer Management > Storage > Disk Management*, but it is not possible to change the partition offset in this tool when data needs to be preserved. *DISKPART* has the same limitations. So, again it is recommended to reinstall Windows\*.



**Note:** Windows\* 2008 and newer would not normally be misaligned, unless the system was a standing upgrade from an earlier version or a clone. In this case, reinstallation is also the best practice.

If reinstalling Windows\* is not an option, there are two possibilities to fix the issue. Download the "Acronis AlignTool – Intel SSD Edition" from [www.intel.com/go/ssd](http://www.intel.com/go/ssd) (search for "Acronis AlignTool"). The software and the instructions are available. This tool has been tested on Windows\* XP and Windows\* Server 2003, but cannot be used on any other OS. It is also possible to use the *GPARTED* procedure below.

### 3.3 Alignment for Linux\*

If a partition is misaligned in Linux\*, and the partition is still empty, it is very easy to remove the partition and recreate it. The best tool for recreating a partition is *GNU parted*, because it will work with both MBR (msdos) disks and GPT disks.

- Run *parted*
- Select the correct disk, *select /dev/sda*
- Remove the current partition that is misaligned, *rm NUMBER* (such as *rm 2*)
- If the partition table type is correct, skip this step:
  - Change the partition table type, *mklabel*
  - Answer prompts: *New disk label type? (msdos or GPT)*
  - The partition table is now rebuilt, enter *print all* to verify
- Create new partition, enter *mkpart*
- Answer the prompts:
  - *Partition name? [ ]?* (this is on GPT only)
  - *File system type? [ext2]?* (*Ext4, Ext3, btrfs*, and so on)
  - *Start? 1MB* (1MB is becoming a fairly common value for partition offset)
  - *End? 400GB* (this will be the size of the partition you want)
  - By using the MB and GB values for your start and end positions, you are able to align the partition where you want it

### 3.4 Re-align Partitions Without Losing Data

If a partition is misaligned and has data that needs to be preserved, using the open source tool *GPARTED* is recommended. *GPARTED* can be downloaded from [gparted.org](http://gparted.org). The live image is the best to use for this purpose.

Procedure for *GPARTED*:

- Before proceeding – BACK UP THE ENTIRE DRIVE – all partitions should be backed up or cloned for DR purposes
- Boot from the *GPARTED* Live CD or USB stick
- In the *gparted* GUI, select your SSD in the upper right drop-down menu
- Click on the first partition
- Click on *Resize/Move*



- Change *Free Space Proceeding* to 2MB
- Uncheck *Round to Cylinders*, or select *Align to: MiB*
- Click on *Resize/Move*
- Click *OK* on the warning page
- Click *Apply*
- Click *Apply* in the warning window
- This process can take a great deal of time, depending on the amount of data
- When the move is complete, close out of *GPARTED* and reboot the system
- In a Windows\* system, if the system fails to boot:
  - Reboot the system using a Windows\* install CD and select *Repair Your Computer*
  - Windows\* should detect the problem and repair the boot menu automatically