

Virtual Hard Disk (VHD) image format

Analysis the Virtual PC VHD format

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Summary

A commonly image format used in Microsoft virtualization products is the Virtual Hard Disk (VHD) Image format. It is both used the store hard disk images (VHD) and snapshots (AVHD).

This document is intended as a working document for the Virtual Hard Disk (VHD) Image format. Which should allow existing Open Source forensic tooling to be able to process this type of disk image format.

Document information

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Abstract: This document contains information about the Virtual Hard Disk (VHD) Image format

Classification: Public

Keywords: Virtual Hard Disk, VHD, Virtual PC, Virtual Server, Hyper-V Server

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Version

Version	Author	Date	Comments
0.0.1	J.B. Metz	September 2012	Initial version
0.0.2	J.B. Metz	September 2012	Additional information and changes.
0.0.3	J.B. Metz	May 2013	Small changes.
0.0.4	J.B. Metz	May 2013	Additional information about undo disks.
0.0.5	J.B. Metz	December 2013	Additional information about parent name.

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1. Overview

A commonly image format used in Microsoft virtualization products is the Virtual Hard Disk (VHD) Image format. It is both used the store hard disk images (VHD) and snapshots (AVHD). The format is the main format used by e.g. Virtual PC, Virtual Server and Hyper-V Server.

Types of images:

- Fixed-size hard disk image
- Dynamic-size (or sparse) hard disk image
- Differential (or differencing) hard disk image

Characteristics	Description
Byte order	big-endian
Date and time values	number of seconds since January 1, 2000 00:00:00 UTC
Character string	Unicode strings are stored in UTF-16 big-endian without the byte order mark (BOM).

1.1. Test version

The following version of programs were used to test the information within this document:

- Virtual PC

1.2. Fixed-size hard disk image

The fixed-size hard disk image consists of:

- data
- footer

1.3. Dynamic-size (or sparse) hard disk image

The dynamic-size (or sparse) hard disk image consists of:

- copy of footer
- dynamic disk header
- block allocation table
- data in blocks
- footer

1.4. Differential hard disk image

The differential (or differencing) hard disk image consists of:

- copy of footer
- dynamic disk header
- block allocation table
- data in blocks
- footer

1.5. Undo disk image

Virtual PC has a feature to create “Undo Disks”. This undo disk feature stores a differential hard disk image in files named something similar like:

```
VirtualPCUndo_<name>_0_0_hhmmssMMDDYYYY.vud
```

Where the date and time seems to be stored in UTC and <name> represents the name of the parent image.

2. Footer

The footer is 512 bytes of size and consists of:

offset	size	value	description
0	8	“conectix”	Signature (Cookie)
8	4		Features
12	4	0x00010000	Format version Where the upper 16-bit are the major version and the lower 16-bit the minor version
16	8		Next offset Offset to the next (metadata) structure. The offset is relative from the start of the file. It should only be set in dynamic and differential disk images. In fixed disk images it should be set to 0xffffffffffff (-1).
24	4		Modification time Contains the number of seconds since January 1, 2000 00:00:00 UTC
28	4		Creator application
32	4		Creator version Where the upper 16-bit are the major version and the lower 16-bit the minor version
36	4		Creator (host) operating system
40	8		Disk size Contains the size of the disk in bytes
48	8		Data size Contains the size of the data in bytes
56	4		Disk geometry
60	4		Disk type
64	4		Checksum
68	16		Identifier Contains a big-endian GUID

offset	size	value	description
84	1		Saved state Flag to indicate the image is in saved state.
85	427	0	Reserved (empty values)

Checksum. It is just a one's complement of the sum of all the bytes in the footer without the checksum field.

2.1. Features

Value	Identifier	Description
0x00000000		No features enabled
0x00000001		Is temporary disk Indicates that this disk is a candidate for deletion on shutdown
0x00000002		Reserved Must always be set to 1

All other bits are also reserved and should be set to 0.

2.2. Creator application

Value	Identifier	Description
“d2v\x00“		Disk2vhd
“qemu”		Qemu
“vpc\x20“		Virtual PC
“vs\x20\x20“		Virtual Server
“win\x20”		Windows (Disk Management)

2.3. Creator host operating system

Value	Identifier	Description
“Mac\x20“		Macintosh
“Wi2k”		Windows

2.4. Disk geometry

The disk geometry is 4 bytes of size and consists of:

offset	size	value	description
0	2		Number of cylinders

offset	size	value	description
2	1		Number of heads
3	1		Number of sectors per track (cylinder)

When a hard disk is configured as an ATA hard disk, the CHS values (that is, Cylinder, Heads, Sectors per track) are used by the ATA controller to determine the size of the disk. When the user creates a hard disk of a certain size, the size of the hard disk image in the virtual machine is smaller than that created by the user. This is because CHS value calculated from the hard disk size is rounded down. The pseudo-code for the algorithm used to determine the CHS values can be found in the appendix of [TECHNET].

2.5. Disk type

Value	Identifier	Description
0		None
1		Reserved (deprecated)
2		Fixed hard disk
3		Dynamic hard disk
4		Differential hard disk
5		Reserved (deprecated)
6		Reserved (deprecated)

3. Dynamic disk header

The dynamic disk header is 1024 bytes of size and consists of:

offset	size	value	description
0	8	“cxsparse”	Signature (Cookie)
8	8		Next offset Offset to the next (metadata) structure. The offset is relative from the start of the file. Currently this is unused and should be set to 0xffffffffffff (-1).
16	8		Block table offset Offset to the block table structure. The offset is relative from the start of the file.
24	4	0x00010000	Format version Where the upper 16-bit are the major version and the lower 16-bit the minor version
28	4		Number of blocks Maximum number of block table entries
32	4		Block size The block size must be a power-of-two

offset	size	value	description
			multitude of the sector size. The default block size is 4096 x 512-byte sectors (2 MB). Does not include the size of the data block bitmap.
36	4		Checksum
40	16		Parent identifier The identifier of the parent. Contains a big-endian GUID Only used by differential hard disk images.
56	4		Parent modification time Contains the number of seconds since January 1, 2000 00:00:00 UTC Only used by differential hard disk images.
60	4		Reserved (empty values)
64	512		Parent name Contains an UTF-16 big-endian string Only used by differential hard disk images.
576	8 x 24 = 192		Array of parent locator entries Only used by differential hard disk images.
768	256		Reserved (empty values)

The maximum number of block table entries should match the maximum possible number of blocks in the disk.

Note that the parent name can also contain a full path, e.g. in .avhd files. The part segments are separated by the \ character.

Checksum. It is just a one's complement of the sum of all the bytes in the footer without the checksum field.

3.1. Parent locator entry

The parent locator entry is 24 bytes of size and consists of:

offset	size	value	description
0	4		Locator platform code
4	4		Platform data space This field stores the number of 512-byte sectors needed to store the parent hard disk locator.
8	4		Locator data size

offset	size	value	description
12	4	0	Reserved (empty values)
16	8		Locator data offset Offset to the locator data. The offset is relative from the start of the file.

3.1.1. Locator platform code

Value	Identifier	Description
0		None
“Max\x20”		Mac OS alias stored as a blob
“MacX”		A file URL with UTF-8 encoding conforming to RFC 2396.
“W2ku”		Absolute Unicode (UTF-16) pathname on Windows.
“W2ru”	W2ru	Unicode path (UTF-16) on Windows relative to the differential disk path.
“Wi2k”		(deprecated)
“Wi2r”	Wi2r	(deprecated)

4. Block table

The block table is only used in dynamic and differential disk images.

The block table consists of 32-bit entries. The entries represent the sector number where the data block starts or unused when set to 0xffffffff (-1).

```
if block table entry == 0xffffffff (-1):
    block is sparse
else:
    data block offset = block table entry x 512
```

Unused block in a dynamic disk are sparse and should be filled with zero byte values. In a differential disks the sparse block is defined in the parent disk image.

5. Data blocks

Data blocks are only used in dynamic and differential disk images.

A data block consists of:

- sector bitmap
- sector data

$$\text{size of bitmap (in bytes)} = \text{block size} / (512 * 8)$$

The size of the bitmap is rounded up to the next multiple of the sector size.

5.1. Data block sector bitmap

In dynamic disk images the sector bitmap indicates which sectors contain data (bit set to 1) or are sparse (bit set to 0).

In differential disk images the sector bitmap indicates which sectors are stored within the image (bit set to 1) or in the parent (bit set to 0).

The bitmap is padded to a 512-byte sector boundary.

6. Notes

Virtual PC fixed disk image, repeated data after initialization:

```
00000000 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 |.....|
*
0007fe80 00 00 00 00 00 00 00 00  cc 68 3c e9 11 44 09 00 |.....h<..D..|
0007fe90 e0 99 21 00 00 00 00 00  e0 ef 83 03 00 00 00 00 |..!.....|
0007fea0 00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 |.....|
*
000ffe80 00 00 00 00 00 00 00 00  cc 68 3c e9 11 44 09 00 |.....h<..D..|
000ffe90 e0 99 21 00 00 00 00 00  e0 ef 83 03 00 00 00 00 |..!.....|
000ffea0 00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 |.....|
*
```

Appendix A. References

[TECHNET]

Title: Virtual Hard Disk Image Format Specification
Author(s): Microsoft
Version: 1.0
Date: October 11, 2006
URL: <http://technet.microsoft.com/en-us/library/bb676673.aspx>

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Version 1.3, 3 November 2008

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