The .ADF (Amiga Disk File) format FAQ

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This document describes the .ADF file format. An Amiga Disk File is a sector per sector dump of an Amiga formatted disk. The intent is to explain in detail how the Amiga stores files and directories on floppy and hard disks.
A set of C routines (ADFlib) will be supplied to manage the ADF format.

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0. Changes

Since 1.11 (August 14th, 2010)

- Typo in 2.3 section. Type of MFM data at 0x40 and 0x240 are BYTE and not LONG, of course.
  Thanks to Bret McGee (http://www.bret-mcgee.me.uk).

Since 1.11 (March 5th, 2005)

- Labelling mistake was in MFM decoding description: odd and even bits was reversed.
  The algorithm was correct, but the associated comments were wrong. Sections 2.1 and 2.3 are now fixed.
  Thanks to Keith Monahan (keith@techtravels.org).

Since 1.10 (November 27th, 2001)

- Links updated
- Amiga Floppy Reader link removed. The project seems cancelled.

Since 1.09 (3. Sep 1999)

- [add] ADFlib is used by ADFview from Bjarke Viksoe

- [chg] URLs fixes

Since 1.08 (2. August 1999)

- [chg] fix: the hashvalue function was buggy on some rare name
- [chg/add] suggestions (last ones) by Hans-Joachim.

Since version 1.07 (27. May 1999)

- [chg] suggestions by Jörg Strohmayer (author of aminet:disk/moni/DiskMonTools.lha)
- [chg] suggestions by Hans-Joachim Widmaier
- [chg] minor additions to the MFM track format, from an online version of "RKRM : Libraries and Devices, appendix C"

Since version 1.06 (2. May 1999), by Heiko Rath (hr@brewhr.swb.de) :

- [chg] Minor spelling corrections
- [chg] Blocksizes other than 512 bytes documented
- [chg] DosEnvVector extended
- [add] link to the Amiga Floppy Reader project

Since version 1.04 (16. January 1999) :

- [chg] Corrections suggested by Hans-Joachim Widmaier (Linux affs maintainer)
- [add] The WinUAE hardfile format section is starting

Since version 0.9 (28. May 1997) :

- [add] HTML version with figures
- [add] Hard disk section added
- [chg] Correction about DIRC and INTL modes (section 4.1)
- [add] The whole rewritten **ADF library** is released (0.7.8) and used within the **ADFOpus** project (New site Gary Harris, Old site Dan Sutherland)
- [chg] The bitmap checksum algorithm is the same as the rootblock algorithm
- [add] Allowed/forbidden characters in volume and file names, 4GB limit
- [add] how to rename an entry

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1. Introduction

In this document, we will describe how the AmigaDOS is (was?) managing storage media, from the magnetic layer to the files and directories layer.

With **physical layer**, I'm talking about the way bytes are physically stored on a magnetic surface, with the RLL or MFM encoding.
The next layer, according to the 'most physical' to 'most conceptual' order, is the **partitions layer** : this is how the AmigaDOS is managing media with more then one partition, like Zip disks or hard disks.
The next and last layer is the **volume layer** : where the files and directories are stored.

The physical layer is described in the 2nd chapter,
The volume layer is the biggest part of the document (4th and 5th chapters), since it's the most interesting,
The partitions layer is explained in the 6th chapter.

Let's continue with more conventional things in an introduction.

1.1 Disclaimer and copyright

1.2 Feedback, updates

If you find any mistakes in this document, have any comments about its content, feel free to send me an e-mail. Corrections are very welcome.

You can find new versions of this document at :

- The ADFlib page : http://lclevy.free.fr/adflib/adf_info.html

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1.3 Conventions

In this document, hexadecimal values use the C syntax : for example 0x0c is the decimal value 12.

Byte ordering

Since the Amiga is a 680x0 based computer, integers that require more than one byte are stored on disk in 'Motorola order' : the most significant byte comes first, then the less significant bytes in descending order of significance (MSB LSB for two-byte integers, B3 B2 B1 B0 for four-byte integers). This is usually called **big endian** byte ordering.
The Intel based PCs are using the **little endian** byte ordering.

Vocabulary

A 'word' or 'short' is a 2-byte (16 bits) integer, a 'long' a 4-byte (32 bits) integer. Values are unsigned unless otherwise noted.

A 'block' in this document will be 512 consecutive bytes on disk, unless noted otherwise, the variable 'BSIZE' will denote the blocksize.
The word 'sector' and 'block' will be used as synonyms here, even if 'sector' is usually related to the physical side, and the 'block' to the logical side. This is because the AmigaDOS can only handle one sector per block. Some other Unix filesystems can have more then one sector per block.

A block pointer is the number of this block on the disk. The first one is the #0 block.
There are 'logical' and 'physical' block pointers. 'Logical' ones are related to the start of one volume, 'physical' one are related to the start of a physical media. If a volume starts at the #0 physical sector, a physical pointer and a logical pointer is the same thing, like with floppies.

A simple definition of 'Hashing' could be : "a method to access tables : given a number or a string, a hash function returns an index into an array". This definition is correct for this document, but there is a lot of other hashing methods, that might be far more complex.

Linked lists are cell-oriented data structures. Each cell contains a pointer to the next or previous cell or both, the last cell pointer is null.

```
C example :

struct lcell {
        char name[10];
        /* contains next cell adress, or NULL if this cell is the last */
        struct lcell *next_cell;
        };
```

Block names begin with a capital (Rootblock). Field names are noted between quotes ('field_name').

All formats are described as tables, one row per field. Here is an example with the beginning of the well known GIF format :

```
offset  type   length  name          comments
----------------------------------------------------------
0       char    3      signature     'GIF'
3       char    3      version       '87a' or '89a'
6       short   1      screen width  (little endian)
8       short   1      screen height (little endian)
```

The .ADF format is the format created and used by the -incredible- UNIX Amiga Emulator (UAE), written by Berndt Schmitt. The home page is here : http://www.freiburg.linux.de/~uae/

The .ADF files can be created with the program **transdisk**.

1.4 Acknowledgements

I would to thank here again the people who take time to send me corrections, suggestions and opinions about this document :

- Hans-Joachim Widmaier for the -very detailed- review and suggestions,
- Dan Sutherland (dan@chromerhino.demon.co.uk) for the suggestions and ideas,
- Jorg Strohmayer (see Aminet:disk/moni/DiskMonTools.lha, his DiskMonTools utility)
- Heiko Rath (hr@brewhr.swb.de) for some modifications.
- Jean Yves Peterschmitt (jypeter@lmce.saclay.cea.fr) for the review,
- Thomas Kessler (tkessler@ra.abo.fi) for the bootcode flag note.
- Keith Monahan (keith@techtravels.org) for the odd / even bits correction.
  See his USB floppy controller project: here

2. How are bytes physically read from / written to a disk ?

The following part deals with the way the Amiga disk controller accesses the magnetic medium. If you only want to understand the .ADF format, you don't need to read this part.

Information is written on disk with magnetic fields. Magnetic fields can be made 'on' or 'off'. But the read/write heads are not capable of detecting directly if a field is on or off. An encoding is used to store memory bits on the medium. The CHANGE of fields polarisation will indicate if the bit is 1 or 0. For Amiga floppy disks (and PC floppies), the encoding scheme is MFM (Modified frequency modulation).

Notes on the Amiga floppy disk controller :

The Amiga floppy disk controller (FDC) which is called 'Paula' is very flexible. It is capable of reading/writting Amiga/PC/Macintosh/AppleII/C64 3.5 inches and 5.25 inches floppy disks.

Paula can read a variable number of bytes from disk, the PC FDC can't. The PC FDC uses the index hole to find the beginning of a track, Paula uses a synchronization word. The Macintosh uses GCR encoding instead of MFM.
In fact, Paula is simpler than the PC FDC because it does not perform automatically the decoding just after the read operation, and the encoding just before the write operation : it must be done by software. The MFM decoding/encoding is done by hardware with the PC FDC, the Amiga can do GCR or MFM decoding/encoding because it's done with the CPU. In some versions of the AmigaDOS, the decoding/encoding is made by the Blitter custom chip.

Classic PC FDCs **can't read Amiga floppy disks** even if they are MFM encoded on a 3.5 inch floppy, because they can not find the beginning of a track. This is why the .ADF format has been created.

However, a custom FDC available on PC machines is capable of reading/writing Amiga, PC, Macintosh, Atari and C64 floppies !!! This is CatWeasel : link

Paula parametrization for Amiga disks :

- MFM encoding
- Precompensation time : 0 nanoseconds
- Controller clock rate : 2 microseconds per bit cell
- Synchronization value : 0x4489

Paula is able to put the read/write heads on a cylinder, and is able to read with the lower or upper side head. A track of 0x1900 words is usually read.

2.1 What is MFM encoding/decoding ?

The MFM decoding is made by the Amiga CPU, not by Paula. This allows custom encoding, to protect floppies against copying for example.

Here follows the MFM encoding scheme :

```
user's data bit      MFM coded bits
---------------      --------------
    1                   01
    0                   10 if following a 0 data bit
    0                   00 if following a 1 data bit
```

User data long words are split in two parts, a part with odd bits part first, followed by a part with even bits. Once encoded, the amount of data stored doubles.
The MFM decoding will transform magnetic fields into computer usuable bits.

The encoding process will take one long (user's data), and produces two longs (MFM coded longs): one for the odd bits of the user long, a second for the even bits of the user long.
Vice versa, the decoding process will take the half of two MFM longs to produce one user's long.

2.2 What is the MFM track format ?

Paula will search two synchronization words, and then read 0x1900 words of data. We will call those 0x1900 words a 'MFM track'.
There are 80 cylinders on a Amiga floppy disk. Each cylinder has 2 MFM tracks, 1 on each side of the disk.

Double density (DD) disks have 11 sectors per MFM track, High density (HD) disks have 22 sectors.

So a MFM track consists of 11/22 MFM encoded sectors, plus inter-track-gap. Note that sectors are not written from #0 to #10/21, you must use the 'info' field to restore the correct order when you read the tracks. Each MFM track begins with the first sector, and ends with the end of the last sector.
Each sector starts with 2 synchronization words. The synchronization value is 0x4489.

2.3 What is the MFM sector format ?

From RKRM: "Per-track Organization: Nulls written as a gap, then 11 or 22 sectors of data. No gaps written between sectors." There are raw data and encoded data.
raw data (also called MFM data) doesn't need to be decoded, this is the synchronization data, the header checksum and data checksum.

The encoded parts are 'header' and 'data'.

Here it comes :

```
00/0x00 word    2       MFM value 0xAAAA AAAA (when decoded : two bytes of 00 data)

        SYNCHRONIZATION
04/0x04 word    1       MFM value 0x4489 (encoded version of the 0xA1 byte)
06/0x06 word    1       MFM value 0x4489

        HEADER
08/0x08 long    1       info (odd bits)
12/0x0c long    1       info (even bits)
                        decoded long is : 0xFF TT SS SG
                                0xFF = Amiga v1.0 format
                                TT = track number ( 3 means cylinder 1, head 1)
                                SS = sector number ( 0 upto 10/21 )
                                        sectors are not ordered !!!
                                SG = sectors until end of writing (including
                                        current one)

                        Example for cylinder 0, head 1 of a DD disk :
                                0xff010009
                                0xff010108
                                0xff010207
                                0xff010306
                                0xff010405
                                0xff010504
                                0xff010603
                                0xff010702
                                0xff010801
```

```
                                0xff01090b
                                0xff010a0a
                        the order of the track written was sector 9, sector 10,
                         sector 0, sector 1 ...

                        (see also the note below from RKRM)

            Sector Label Area : OS recovery info, reserved for future use

16/0x10 long    4       sector label (odd)
32/0x20 long    4       sector label (even)
                    decoded value is always 0

            This is operating system dependent data and relates to how AmigaDOS
            assigns sectors to files.

            Only available to 'trackdisk.device', but not with any other floppy
            or hard disk device.

        END OF HEADER

48/0x30 long    1       header checksum (odd)
52/0x34 long    1       header checksum (even)
                        (computed on mfm longs,
                        longs between offsets 8 and 44
                        == 2*(1+4) longs)

56/0x38 long    1       data checksum (odd)
60/0x3c long    1       data checksum (even)
                        (from 64 to 1088 == 2*512 bytes)

        DATA
64/0x40   byte  512     coded data (odd)
576/0x240 byte  512     coded data (even)
1088/0x440
        END OF DATA
```

Note from RKRM :

```
The track number and sector number are constant for each particular
sector. However, the sector offset byte changes each time we rewrite
the track.

The Amiga does a full track read starting at a random position on the
track and going for slightly more than a full track read to assure
that all data gets into the buffer. The data buffer is examined to
determine where the first sector of data begins as compared to the
start of the buffer. The track data is block moved to the beginning
of the buffer so as to align some sector with the first location in
the buffer.

Because we start reading at a random spot, the read data may be
divided into three chunks: a series of sectors, the track gap, and
another series of sectors. The sector offset value tells the disk
software how many more sectors remain before the gap. From this the
software can figure out the buffer memory location of the last byte
of legal data in the buffer. It can then search past the gap for the
next sync byte and, having found it, can block move the rest of the
disk data so that all 11 sectors of data are contiguous.

    Example:

        The first-ever write of the track from a buffer looks
        like this:
```

```
          |sector0|sector1|sector2|......|sector10|

         sector offset values:

                    11      10      9     .....     1

         (If I find this one at the start of my read buffer, then I
          know there are this many more sectors with no intervening
          gaps before I hit a gap).  Here is a sample read of this
          track:

         |sector9|sector10||sector0|...|sector8|

         value of 'sectors till end of write':

                    2        1     ....    11   ...    3

         result of track re-aligning:

         |sector9|sector10|sector0|...|sector8|

         new sectors till end of write:

                   11       10      9    ...     1

         so that when the track is rewritten, the sector offsets
         are adjusted to match the way the data was written.
```

2.4 How to decode MFM data ?

```
C algorithm :


#define MASK 0x55555555 /* 01010101 ... 01010101 */
unsigned long *input;   /* MFM coded data buffer (size == 2*data_size) */
unsigned long *output;  /* decoded data buffer (size == data_size) */
unsigned long odd_bits, even_bits;
unsigned long chksum;
int data_size;          /* size in long, 1 for header's info, 4 for header's sector label */
int count;

chksum=0L;
/* the decoding is made here long by long : with data_size/4 iterations */
for (count=0; count<data_size/4; count++) {
        odd_bits = *input;                /* longs with odd bits */
        even_bits = *(input+data_size);    /* longs with even bits : located 'data_size' bytes
        chksum^=odd_bits;              /* eor */
        chksum^=even_bits;
        /*
         * MFM decoding, explained on one byte here (o and e will produce t) :
         * the MFM bytes 'abcdefgh' == o and 'ijklmnop' == e will become
         * e & 0x55U = '0j0l0n0p'
         * ( o & 0x55U) << 1 = 'b0d0f0h0'
         * '0j0l0n0p' | 'b0d0f0h0' = 'bjdlfnhp' == t
         */
        /* on one long here : */
        *output = ( even_bits & MASK ) | ( ( odd_bits & MASK ) << 1 );
        input++;    /* next 'odd' long and 'even bits' long  */
        output++;     /* next location of the future decoded long */
        }
chksum&=MASK;   /* must be 0 after decoding */
```

For example, to decode the DATA field of a MFM sector :

- 'data_size' is equal to 512,
- 'input' points to 64 bytes after the beginning of the MFM sector,
- 'output' points to a 512 unsigned bytes array.

---

3. What is the Amiga floppy disk geometry ?

After MFM decoding, you have usuable 'sectors' or 'blocks' into memory.

Here we remind the disk geometries for Double Density disks (DD) and High Density disks (HD) :

```
                bytes/sector    sector/track    track/cyl       cyl/disk
------------------------------------------------------------------------
DD disks        512             11              2               80
HD disks        512             22              2               80
```

The relations between sectors, sides and cylinders are for a DD disk :

```
Block   sector  side    cylinder
--------------------------------
0       0       0       0
1       1       0       0
2       2       0       0
...
10      10      0       0
11      0       1       0
...
21      10      1       0
22      0       0       1
..
1759    10      1       79
```

Order = increasing sectors, then increasing sides, then increasing cylinders.

A DD disk has 11*2*80=1760 (0 to 1759) blocks, a HD disk has 22*2*80=3520 blocks.

The length of .ADF files for a DD disk is therefore 512*11*2*80 = 901120 bytes.

Those 'raw' blocks, 512 consecutive bytes, store different 'logical' blocks to manage files and directories.

The classic Amiga filesystem has a internal command with one 32 bits wide offset parameter (unsigned). It tells where to start the read/write operation. The biggest size for an Amiga disk is therefore 2^32 = 4 GB. Anyway, there exists a 3rd party patch which changes the 32 bits limit to 64 bits (on Aminet, disk/misc /ffstd64.lha).

Jorg Strohmayer added :
TD64 is an unofficial 3rd party hack. Official solution is NSD (new style device), updates for the internal devices and the filesystem are available from http://www.amiga.de. There is a patch for old (and TD64) devices too (NSDPatch).

---

4. What is the logical organisation of an Amiga volume ?

A volume is a floppy disk or a hard disk partition.

The first file system for the Amiga was embedded in the version 1.2 of AmigaDOS.

With version 2.xx of AmigaDOS the Fast File System (FFS) was introduced, an improved version of the 1.2, also called old file system (OFS).
The version 3.0 of AmigaDOS added an international characters mode (INTL) and a directory cache mode (DIRC).

Links are only supported under FFS.

The start of a floppy volume contains space for sectors which may contain boot code.
The middle of the volume contains information about the root (upper most) directory contents and information about free and used blocks.
Other blocks are of course used to store files and directories.

The file length, the directory tree depth, the number of entries per directory are only limited by disk size. (Actually the maximum filesize is limited to 4 Gbyte sizeof(ulong) which should normally be more than sufficient).

Let's introduce the logical structures used by the Amiga file system in a table (for floppies) :

```
Object          Related logical blocks
------------+----------------------------------------------------------------
Volume          Rootblock, Bitmap block
File            File Header block, Extension block, Data block, Link block
Directory       Rootblock, Directory block, Directory Cache block, Link block
```

The main data types are a trees and linked lists.

4.1 What is a Bootblock ?

Prior to Kickstart 2.0 the bootblock was hardcoded to consist of the first two sectors of the floppy disks (sector #0 and #1). As of Kick 2.0, booting via the boot-block could be done with any device driver and the number of blocks could be changed independantly of the number of reserved blocks by using BOOTBLOCKS in the DOS environment vector (DosEnvVec).

```
* BootBlock
-------------------------------------------------------------------------------
offset  size    number  name            meaning
-------------------------------------------------------------------------------
0/0x00  char    4       DiskType        'D''O''S' + flags
                                        flags = 3 least signifiant bits
                                               set          clr
                                          0    FFS          OFS
                                          1    INTL ONLY    NO_INTL ONLY
                                          2    DIRC&INTL    NO_DIRC&INTL
4/0x04  ulong   1       Chksum          special block checksum
8/0x08  ulong   1       Rootblock       Value is 880 for DD and HD
                                         (yes, the 880 value is strange for HD)
12/0x0c char    *       Bootblock code  (see 5.2 'Bootable disk' for more info)
                                        The size for a floppy disk is 1012,
                                        for a harddisk it is
                                        (DosEnvVec->Bootblocks * BSIZE) - 12
-------------------------------------------------------------------------------
```

The DiskType flag informs of the disk format.

- OFS = Old/Original File System, the first one. (AmigaDOS 1.2)
- FFS = Fast File System (AmigaDOS 2.04)

- INTL = International characters Mode (see section 5.4).
- DIRC = stands for Directory Cache Mode. This mode speeds up directory listing, but uses more disk space (see section 4.7).

The Old filesystem may have the international and dircache mode enabled. If the international mode is enabled, the bit #1 is set. If the dircache is enabled, its flag is set (bit #2), **and the international mode is also enabled, but the related flag (bit #1) will stay cleared**. The correct values for flag are therefore : 0 (OFS), 1 (FFS), 2 (OFS/INTL), 3 (FFS/INTL), 4 (OFS/DIRC&INTL), 5 (FFS/DIRC&INTL).

There are few differences between the two file systems :

- OFS Datablock stores BSIZE-24 bytes (i.e. normally 488 bytes at most frequently used BSIZE of 512 bytes), FFS stores BSIZE bytes.
- FFS supports directory caching, links and international mode,
- the FFS is faster than OFS.

If the Bootblock starts with the three characters 'PFS', another filesystem is used in place of AmigaDOS : the Professional File System.

If the checksum and the DiskType are correct, the system will execute the bootblock code, at boot time, of course :-).

The Bootblock code is optional, see 5.2 section.

The Bootblock checksum algorithm follows :

```
* in 68000 assembler :

        lea     bootbuffer,a0
        move.l  a0,a1
        clr.l   4(a1)                   ;clear the checksum
        move.w  #(BOOTBLOCKSIZE/4)-1,d1 ;for floppy disks = 1024
                                        ;for hd = (DosEnvVec->Bootblocks * BSIZE)
        moveq   #0,d0
lpchk:  add.l   (a0)+,d0                ;accumulation
        bcc.s   jump                    ;if carry set, add 1 to checksum
        add.l   #1,d0
jump:   dbf     d1,lpchk                ;next long word

        not.l   d0
        move.l  d0,4(a1)                ;new checksum


* in C (version 1):

#include<limits.h>
#define Short(p)  ((p)[0]<<8 | (p)[1])
#define Long(p)  (Short(p)<<16 | Short(p+2))

unsigned long newsum,d;
unsigned char buf[BOOTBLOCKSIZE];       /* contains bootblock */
                                        /* for floppy disks = 1024, */
                                        /* for hard disks = (DosEnvVec->Bootblocks * BSIZE) */
int i;

memset(buf+4,0,4);                      /* clear old checksum */
newsum=0L;
for(i=0; i<BOOTBLOCKSIZE/4; i++) {
        d=Long(buf+i*4);
```

```
        if ( (ULONG_MAX-newsum) < d )   /* overflow */
                newsum++;
        newsum+=d;
}

newsum=~newsum;         /* not */



* version 2 (From Ralph Babel's 'Install2.c', sent by Hans-Joachim)


unsigned long checksum, precsum;

checksum = 0;
for(i=0; i<BOOTBLOCKSIZE/sizeof(unsigned long); i++) {
    precsum = checksum;
    if ( (checksum+=Long(buf+i*4)) < precsum)   /* better 68000 to C translation of 'bcc' */
        ++checksum;
}
checksum = ~checksum;
```

4.2 What is a Rootblock ?

The Rootblock is located at the physical middle of the media : block number 880 for DD disks, block 1760 for HDs. The exact calculation where it is stored is as follows:

numCyls = highCyl - lowCyl + 1

highKey = numCyls * numSurfaces * numBlocksPerTrack - 1

rootKey = INT (numReserved + highKey) / 2

The Rootblock contains information about the disk : its name, its formatting date, etc ...

It also contains information to access the files/directories/links located at the uppermost (root) directory.

```
* Root block (BSIZE bytes) sector 880 for a DD disk, 1760 for a HD disk
------------------------------------------------------------------------------------------------
        0/ 0x00 ulong   1       type            block primary type = T_HEADER (value 2)
        4/ 0x04 ulong   1       header_key      unused in rootblock (value 0)
                ulong   1       high_seq        unused (value 0)
       12/ 0x0c ulong   1       ht_size         Hash table size in long (= BSIZE/4 - 56)
                                                For floppy disk value 0x48
       16/ 0x10 ulong   1       first_data      unused (value 0)
       20/ 0x14 ulong   1       chksum          Rootblock checksum
       24/ 0x18 ulong   *       ht[]            hash table (entry block number)
                                                * = (BSIZE/4) - 56
                                                for floppy disk: size= 72 longwords
BSIZE-200/-0xc8 ulong   1       bm_flag         bitmap flag, -1 means VALID
BSIZE-196/-0xc4 ulong   25      bm_pages[]      bitmap blocks pointers (first one at bm_pages[
BSIZE- 96/-0x60 ulong   1       bm_ext          first bitmap extension block
                                                (Hard disks only)
BSIZE- 92/-0x5c ulong   1       r_days          last root alteration date : days since 1 jan 7
BSIZE- 88/-0x58 ulong   1       r_mins          minutes past midnight
BSIZE- 84/-0x54 ulong   1       r_ticks         ticks (1/50 sec) past last minute
BSIZE- 80/-0x50 char    1       name_len        volume name length
BSIZE- 79/-0x4f char    30      diskname[]      volume name
```

```
BSIZE- 49/-0x31 char    1       UNUSED          set to 0
BSIZE- 48/-0x30 ulong   2       UNUSED          set to 0
BSIZE- 40/-0x28 ulong   1       v_days          last disk alteration date : days since 1 jan 7
BSIZE- 36/-0x24 ulong   1       v_mins          minutes past midnight
BSIZE- 32/-0x20 ulong   1       v_ticks         ticks (1/50 sec) past last minute
BSIZE- 28/-0x1c ulong   1       c_days          filesystem creation date
BSIZE- 24/-0x18 ulong   1       c_mins
BSIZE- 20/-0x14 ulong   1       c_ticks
                ulong   1       next_hash       unused (value = 0)
                ulong   1       parent_dir      unused (value = 0)
BSIZE-  8/-0x08 ulong   1       extension       FFS: first directory cache block,
                                                0 otherwise
BSIZE-  4/-0x04 ulong   1       sec_type        block secondary type = ST_ROOT
                                                (value 1)
------------------------------------------------------------------------------------------------
```

The characters '/' and ':' are forbidden in file and volume names, but `*!@#$%|^+&_()=\-[]{}';",<>.?` and accented like `âè` are allowed.

The date fields in the root block (and other blocks) are structured in the form of DAYS, MINS and TICKS. The DAYS field contains the number of days since January 1. 1978. MINS is the number of minutes that have passed since midnight and TICKS are expressed in 1/50s of a second. A day value of zero is considered illegal by most programs.

The r_date / r_min / r_ticks fields are updated to the last recent change of the root directory of this volume.

The v_date / v_min / v_ticks fields are updated whenever any change was made to this volume, not just the root directory.

The c_date / c_min / c_ticks fields contain the date and time when this volume was initialized (i.e. formatted) and is not changed during its lifetime.

Some date constraints : 0 <= Mins < 60*24, 0 <= Ticks < 50*60

The Amiga filesystem does not have an inherent year 2000 problem. If you want to know more about Y2K and the Amiga, you might take a look at : http://www.amiga.com.

4.2.1 How to find the first sector of a directory entry ?

Given the name of a file/directory/link you first have to compute its hash value with this algorithm :

* The hash function :

```
#include<ctype.h>

int HashName(unsigned char *name)
{
unsigned long hash, l;                          /* sizeof(int)>=2 */
int i;

l=hash=strlen(name);
for(i=0; i<l; i++) {
        hash=hash*13;
        hash=hash + toupper(name[i]);   /* not case sensitive */
        hash=hash & 0x7ff;
        }
hash=hash % ((BSIZE/4)-56);             /* 0 < hash < 71
                                         * in the case of 512 byte blocks */
```

```
return(hash);
}

// this code only works with non international mode disks
// see section 5.4
```

The **toupper()** function is the one thing that distinguishes international from non-international filesystems. There was a bug in old AmigaDOS versions for this function applied to international caracters (ASCII codes > 128). A specific toupper() function (see section 5.4) was then created available with the 'international mode'.

The hash value is then used to access HashTable ('ht' field in Rootblock/Directory block).

HashTable[HashValue] contains the number of the first block of your object (File header block, Directory block or Link block).

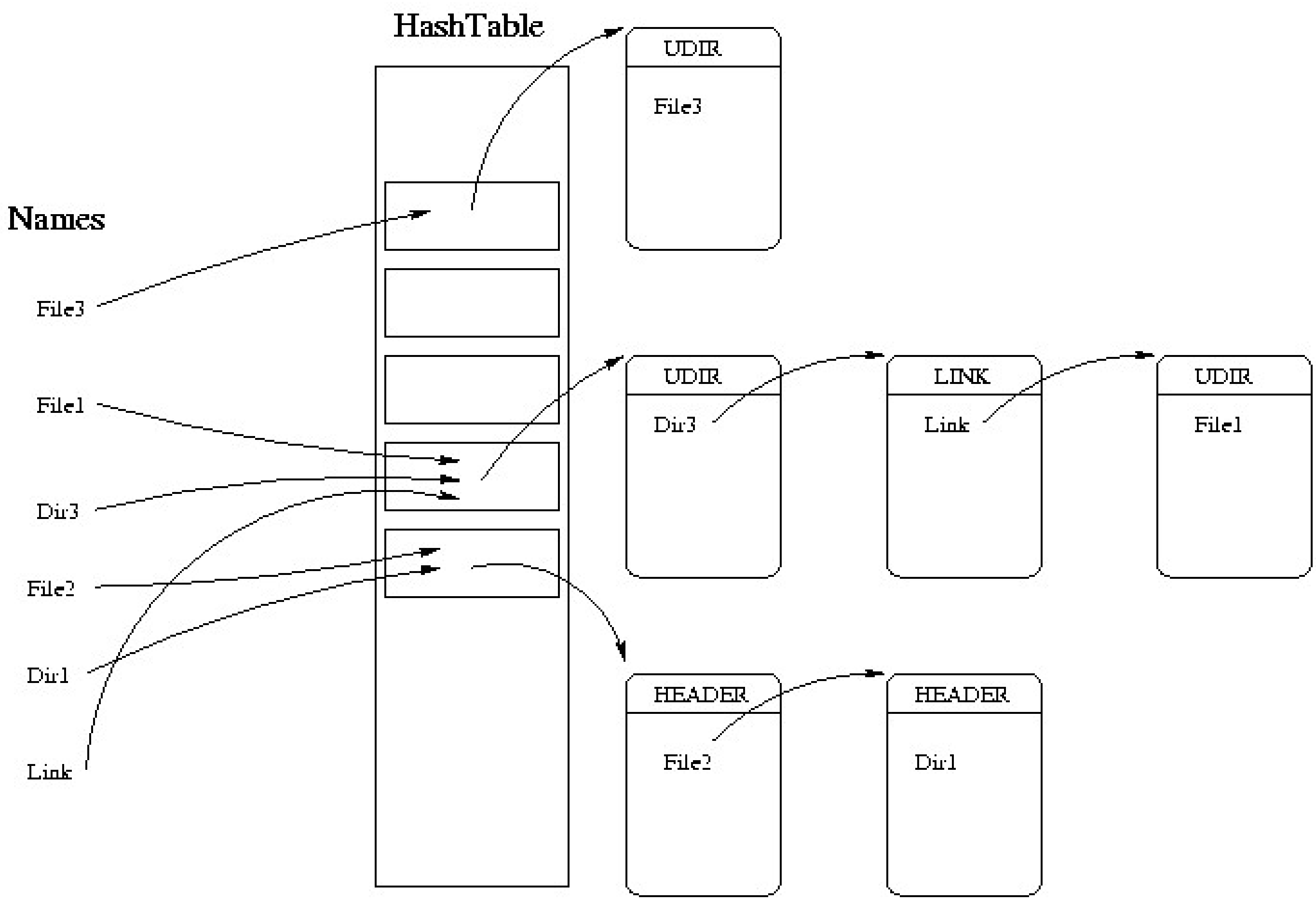
But different names can result in the same HashValue. If more then one name has the same HashValue, the other blocks (for files and directory only) are stored in a chained list. This linked list starts at the 'next_hash' field of the File header or Directory block.

For example : 'file_1a', 'file_24' and 'file_5u' have the same hash value.

Here follows the method to find the requested block :

```
HashValue = HashName( name );
name=uppercase(name);
nsector = Hashtable[ HashValue ];
if (nsector != 0) {
        sector=Load(nsector);           /* reads the 'nsector' sector */
        sector.name = uppercase(sector.name);
        /*
         *  follows the 'same HashValue' chained list if needed
         */
        while ( sector.name != name and sector.Next_hash != 0) {
                sector = Load(nsector);
                sector.name = uppercase(sector.name);
        }
        if (sector.name != name)
                puts("File/Dir not found");
}
else
        puts("File/Dir not found");


// this code only works with non international mode disks
// see section 5.4
```



"File1", "Dir3" and "Link" have the same HashValue. "File2" and "Dir1" have the same HashVal

Filenames characters can be lowercase and uppercase, but as shown in the Hash function, are not case sensitive.

If, for a new entry, the value at hashTable[hashvalue] is different than 0, the new sector pointer will be stored in the last entry of the same-hashvalue-linked-list. It is necessary to check if the entry name already exists in this directory. In one word, in the same-hashValue list, the addition is made at the tail, not the head.
Jorg tells the list is instead sorted by block number.

4.2.2 How to list all the directory entries ?

Look through the whole HashTable and follow the same 'HashValue' linked lists if they exist.

4.2.3 How to compute the checksum ?

```
#define Short(p) ((p)[0]<<8 | (p)[1])
#define Long(p) (Short(p)<<16 | Short(p+2))

unsigned long newsum;
unsigned char buf[BSIZE];        /* contains rootblock */
int i;

memset(buf+20,0,4);              /* clear old checksum */
```

```
newsum=0L;
for(i=0; i<(BSIZE/4); i++)
        newsum+=Long(buf+i*4);
newsum=-newsum;                  /* negation */
```

This checksum algorithm works for most block types except for Bootblock.

The bitmap table ('bm_pages[]') stores one or several pointers to Bitmap blocks. The first pointer is at index 0.

4.3 How are the free and used block lists managed?

Bitmap blocks contain information about free and allocated blocks. One bit is used per block. If the bit is set, the block is free, a cleared bit means an allocated block.

Bootblock allocation (2 for floppy, for hard disks the value can be found at DOSEnvVec->Bootblocks) is not stored in bitmap. Bitmap consists of longs, each describing the status of 32 blocks, where bit 0 corresponds to the lowest block number.

```
* Bitmap block (BSIZE bytes), often at rootblock+1
------------------------------------------------------------------------------------
0/0x00  long    1               checksum        normal algorithm
4/0x04  long    (BSIZE/4)-1     map
------------------------------------------------------------------------------------
```

Here follows for a DD disk the relationship between bitmap and block number :

```
block #         long #  bit #
-------------------------------
2               0       0
3               0       1
4               0       2
...
33              0       31
34              1       0
35              1       1
...
880             27      14
881             27      15
...
1759            54      28
1760            54      29
```

This map is 1758 bits long (1760-2) and is stored on 54 full filled long and the first 30th bits of the 55th long.

* What is the 'bm_ext' field in Rootblock ?

If 25 bitmap blocks (which pointers are stored in the Rootblock) are not sufficient (for Hard Disks > ca. 50 Mbyte), the pointers to the further bitmap blocks are stored in so called bitmap extension blocks. The form a (surprise, surprise!) linked list, starting at the bm_ext field in the Rootblock.

```
* Bitmap extension block (BSIZE bytes) (Hard disk only)
------------------------------------------------------------------------------------
       0/0x00   ulong   (BSIZE/4)-1     bitmap block pointers
BSIZE- 4/0x04   ulong   1               next (0 for last)
------------------------------------------------------------------------------------
```

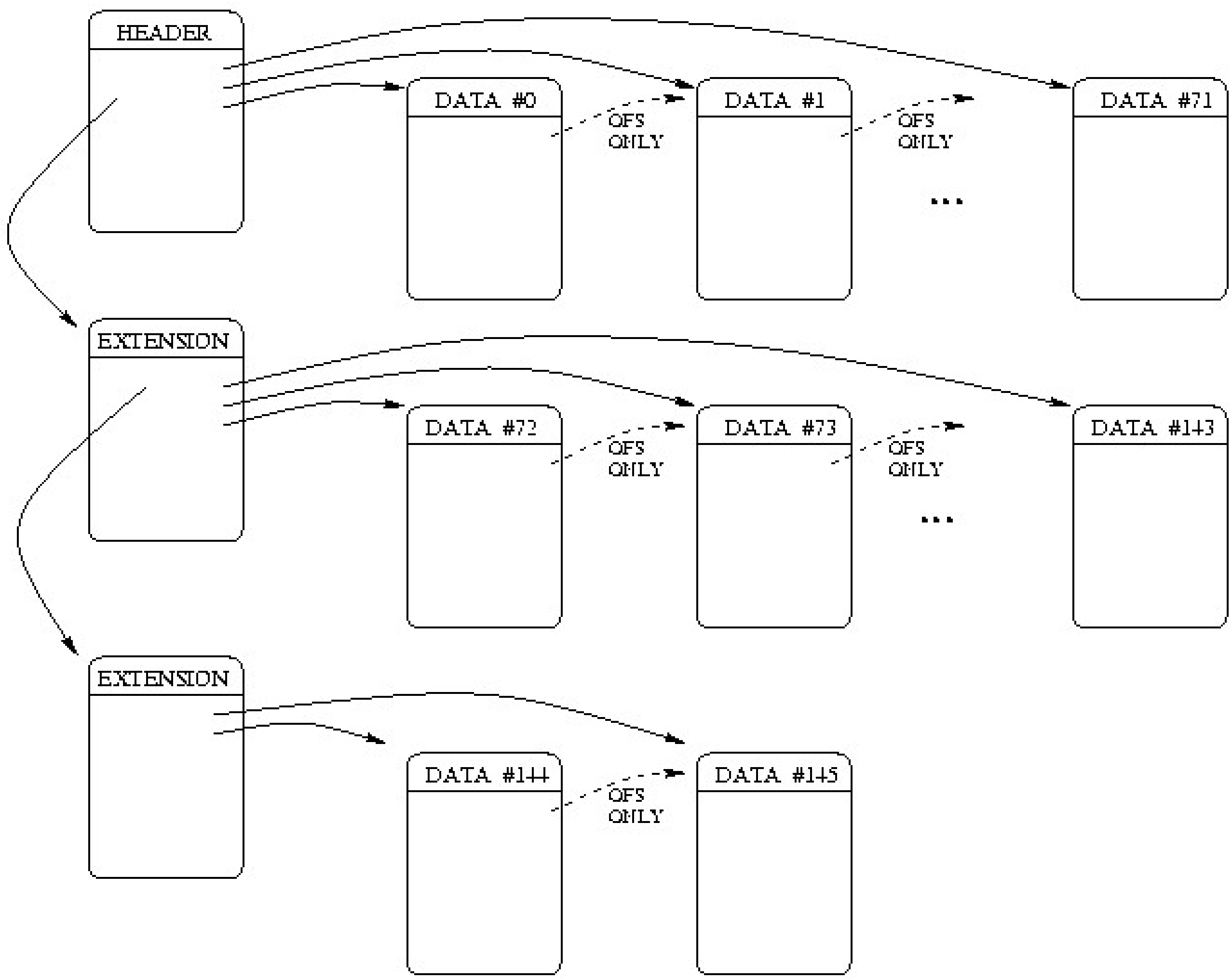
The Bitmap extension linked list start at Rootblock with the 'bm_ext'.

4.4 How are files stored ?

Files are comprised of a file header block, which contains information about the file (size, last access time, data block pointers, ...) and the data blocks, which contain the actual data. The file header block contains up to BSIZE/4-56 data block pointers (which amounts to 72 with the usual 512 byte blocks).

If a file is larger than that, file extension blocks will be allocated to hold the data block pointers.

File extension blocks are organised in a linked list, which starts in File header block ('extension' field).




```
* File header block (BSIZE bytes)
------------------------------------------------------------------------------------------------
        0/ 0x00 ulong   1       type            block primary type T_HEADER (==2)
        4/ 0x04 ulong   1       header_key      self pointer (to this block)
        8/ 0x08 ulong   1       high_seq        number of data block ptr stored here
       12/ 0x0c ulong   1       data_size       unused (==0)
       16/ 0x10 ulong   1       first_data      first data block ptr
       20/ 0x14 ulong   1       chksum          same algorithm as rootblock
       24/ 0x18 ulong   *       data_blocks[]   data blk ptr (first at BSIZE-204 )
                                                * = (BSIZE/4) - 56
BSIZE-200/-0xc8 ulong   1       UNUSED          == 0
BSIZE-196/-0xc4 ushort  1       UID             UserID
BSIZE-194/-0xc4 ushort  1       GID             GroupID
BSIZE-192/-0xc0 ulong   1       protect         protection flags (set to 0 by default)
```

```
                                     Bit     If set, means

                                        If MultiUser FileSystem : Owner
                                      0       delete forbidden (D)
                                      1       not executable (E)
                                      2       not writable (W)
                                      3       not readable (R)

                                      4       is archived (A)
                                      5       pure (reetrant safe), can be made resident (P)
                                      6       file is a script (Arexx or Shell) (S)
                                      7       Hold bit. if H+P (and R+E) are set the file
                                               can be made resident on first load (OS 2.x an

                                      8       Group (D) : is delete protected
                                      9       Group (E) : is executable
                                     10       Group (W) : is writable
                                     11       Group (R) : is readable

                                     12       Other (D) : is delete protected
                                     13       Other (E) : is executable
                                     14       Other (W) : is writable
                                     15       Other (R) : is readable
                                  30-16       reserved
                                     31       SUID, MultiUserFS Only

BSIZE-188/-0xbc ulong   1       byte_size       file size in bytes
BSIZE-184/-0xb8 char    1       comm_len        file comment length
BSIZE-183/-0xb7 char    79      comment[]       comment (max. 79 chars permitted)
BSIZE-104/-0x69 char    12      UNUSED          set to 0
BSIZE- 92/-0x5c ulong   1       days            last change date (days since 1 jan 78)
BSIZE- 88/-0x58 ulong   1       mins            last change time
BSIZE- 84/-0x54 ulong   1       ticks            in 1/50s of a seconds
BSIZE- 80/-0x50 char    1       name_len        filename length
BSIZE- 79/-0x4f char    30      filename[]      filename (max. 30 chars permitted)
BSIZE- 49/-0x31 char    1       UNUSED          set to 0
BSIZE- 48/-0x30 ulong   1       UNUSED          set to 0
BSIZE- 44/-0x2a ulong   1       real_entry      FFS : unused (== 0)
BSIZE- 40/-0x28 ulong   1       next_link       FFS : hardlinks chained list (first=newest)
BSIZE- 36/-0x24 ulong   5       UNUSED          set to 0
BSIZE- 16/-0x10 ulong   1       hash_chain      next entry ptr with same hash
BSIZE- 12/-0x0c ulong   1       parent          parent directory
BSIZE-  8/-0x08 ulong   1       extension       pointer to 1st file extension block
BSIZE-  4/-0x04 ulong   1       sec_type        secondary type : ST_FILE (== -3)
------------------------------------------------------------------------------------------------
```

As with volume names ':' and '/' are forbidden in file names.

The number of blocks used to store a file depends on the filesystem used, OFS or FFS. If one file has 7 datablocks, the first is at datablock[71-0], the last at datablocks[71-6], and highseq equals to 7.

For the OFS there are two ways of reading the contents of a file. First by traversing the linked list of data blocks that is pointed to in first_data (offset 16) and then following the pointers in each file data block. The other way of accessing the file data is by using the data_blocks[] table and going backwards through the data blocks listed there and then the File extension blocks.

As the FFS doesn't contain extra information in the data blocks (no pointer list, no checksum) the only way of accessing the file contents is by going through the data_blocks[] table and the File extension blocks.

An empty file consists of just a File header block, with 'byte_size' equal to 0, and no Data block pointers in 'data_blocks[]'.

```
* File extension block (BSIZE bytes) (first pointer in File header)
------------------------------------------------------------------------------------------------
        0/ 0x00 ulong   1       type            primary type : T_LIST (== 16)
        4/ 0x04 ulong   1       header_key      self pointer
        8/ 0x08 ulong   1       high_seq        number of data blk ptr stored
       12/ 0x0c ulong   1       UNUSED          unused (== 0)
       16/ 0x10 ulong   1       UNUSED          unused (== 0)
       20/ 0x14 ulong   1       chksum          rootblock algorithm
       24/ 0x18 ulong   *       data_blocks[]   data blk ptr (first at BSIZE-204)
                                                * = (BSIZE/4) - 56
BSIZE-200/-0xc8 ulong   46      info            unused (== 0)
BSIZE- 16/-0x10 ulong   1       UNUSED          unused (== 0)
BSIZE- 12/-0x0c ulong   1       parent          file header block
BSIZE-  8/-0x08 ulong   1       extension       next file header extension block,
                                                0 for the last
BSIZE-  4/-0x04 ulong   1       sec_type        secondary type : ST_FILE (== -3)
------------------------------------------------------------------------------------------------
```

* Data blocks (BSIZE bytes) (first pointer in File header 'first_data' and 'data_blocks[((BSIZE/4)-57)]')

```
Old File System data block (BSIZE bytes)
--------------------------------------------------------------------------------
0/0     ulong   1       type            primary type : T_DATA (== 8)
4/4     ulong   1       header_key      pointer to file header block
8/8     ulong   1       seq_num         file data block number (first is #1)
12/c    ulong   1       data_size       data size <= (BSIZE-24)
16/10   ulong   1       next_data       next data block ptr (0 for last)
20/14   ulong   1       chksum          rootblock algorithm
24/18   UCHAR   *       data[]          file data size <= (BSIZE-24)
--------------------------------------------------------------------------------
```

In OFS, there is a second way to read a file : using the Data block chained list. The list starts in File header ('first_data') and goes on with 'next_data' in each Data block.

```
Fast File System (BSIZE bytes)
--------------------------------------------------------------------------------
0/0     UCHAR   BSIZE   data[]          file data
--------------------------------------------------------------------------------
```

In FFS, the only way to read or recover a file is to use data_blocks[] in the file header block and the File extension blocks. If a File header or File extension block is unreadable, there is no way to find the corresponding Data blocks.

The OFS is more robust than FFS, but slower and can store less data on disk. As you see, disk salvaging is easier with OFS.

When a file is deleted, only its File header block number is cleared from the Directory block (or from the same-hash-value list) and the bitmap is updated. File header block, Data blocks and File extension blocks are not cleared, but the bitmap blocks are updated. Nevertheless, the undelete operation is easy, as long as these blocks are not overwritten.

4.5 How are directories stored?

Directory blocks are very similar to Rootblock, except they don't need information about the bitmap and disk, but they allow comments like files.

```
* User directory block (BSIZE bytes)
------------------------------------------------------------------------------------------------
        0/ 0x00 ulong   1       type            block primary type = T_HEADER (value 2)
```

```
        4/ 0x04 ulong   1       header_key      self pointer
        8/ 0x08 ulong   3       UNUSED          unused (== 0)
       20/ 0x14 ulong   1       chksum          normal checksum algorithm
       24/ 0x18 ulong   *       ht[]            hash table (entry block number)
                                                * = (BSIZE/4) - 56
                                                for floppy disk: size= 72 longwords
BSIZE-200/-0xc8 ulong   2       UNUSED          unused (== 0)
BSIZE-196/-0xc8 ushort  1       UID             User ID
BSIZE-194/-0xc8 ulong   1       GID             Group ID
BSIZE-192/-0xc0 ulong   1       protect         protection flags (set to 0 by default)

                                        Bit     If set, means

                                           If MultiUser FileSystem : Owner
                                        0       delete forbidden (D)
                                        1       not executable (E)
                                        2       not writable (W)
                                        3       not readable (R)

                                        4       is archived (A)
                                        5       pure (reetrant safe), can be made resident (P)
                                        6       file is a script (Arexx or Shell) (S)
                                        7       Hold bit. if H+P (and R+E) are set the file
                                                 can be made resident on first load (OS 2.x an

                                        8       Group (D) : is delete protected
                                        9       Group (E) : is executable
                                       10       Group (W) : is writable
                                       11       Group (R) : is readable

                                       12       Other (D) : is delete protected
                                       13       Other (E) : is executable
                                       14       Other (W) : is writable
                                       15       Other (R) : is readable
                                    30-16       reserved
                                       31       SUID, MultiUserFS Only

BSIZE-188/-0xbc ulong   1       UNUSED          unused (== 0)
BSIZE-184/-0xb8 char    1       comm_len        directory comment length
BSIZE-183/-0xb7 char    79      comment[]       comment (max. 79 chars permitted)
BSIZE-104/-0x69 char    12      UNUSED          set to 0
BSIZE- 92/-0x5c ulong   1       days            last access date (days since 1 jan 78)
BSIZE- 88/-0x58 ulong   1       mins            last access time
BSIZE- 84/-0x54 ulong   1       ticks           in 1/50s of a seconds
BSIZE- 80/-0x50 char    1       name_len        directory name length
BSIZE- 79/-0x4f char    30      dirname[]       directory (max. 30 chars permitted)
BSIZE- 49/-0x31 char    1       UNUSED          set to 0
BSIZE- 48/-0x30 ulong   2       UNUSED          set to 0
BSIZE- 40/-0x28 ulong   1       next_link       FFS : hardlinks chained list (first=newest)
BSIZE- 36/-0x24 ulong   5       UNUSED          set to 0
BSIZE- 16/-0x10 ulong   1       hash_chain      next entry ptr with same hash
BSIZE- 12/-0x0c ulong   1       parent          parent directory
BSIZE-  8/-0x08 ulong   1       extension       FFS : first directory cache block
BSIZE-  4/-0x04 ulong   1       sec_type        secondary type : ST_USERDIR (== 2)
------------------------------------------------------------------------------------------------
```

You can obtain a directory listing exactly like with the root directory.

4.6 How are links implemented in AmigaDOS ?

With the FFS, links were introduced. Alas, Commodore blundered again: soft like where terribly broken, so they removed support for them in AmigaDOS 3.0. Hard links are seen as files, and hard links to directories are

allowed, which opens the way to endless recursion...
In short, the whole implmentation is a mess.
However, some shells (like Csh 5.37) support them, so I'm supplying the structure.

4.6.1 Hard links

```
* Hard link (BSIZE bytes)
------------------------------------------------------------------------------------------------
        0/ 0x00 ulong   1       type            block primary type = T_HEADER (value 2)
        4/ 0x04 ulong   1       header_key      self pointer
        8/ 0x08 ulong   3       UNUSED          unused (== 0)
       20/ 0x14 ulong   1       chksum          normal checksum algorithm
       24/ 0x18 ulong   *       UNUSED          set to 0
                                                * = (BSIZE/4) - 54
                                                for floppy disk: size= 74 longwords
BSIZE-192/-0xc0 ulong   1       protect         protection flags (set to 0 by default)

                                        Bit     If set, means

                                           If MultiUser FileSystem : Owner
                                        0       delete forbidden (D)
                                        1       not executable (E)
                                        2       not writable (W)
                                        3       not readable (R)

                                        4       is archived (A)
                                        5       pure (reetrant safe), can be made resident (P)
                                        6       file is a script (Arexx or Shell) (S)
                                        7       Hold bit. if H+P (and R+E) are set the file
                                                 can be made resident on first load (OS 2.x an

                                        8       Group (D) : is delete protected
                                        9       Group (E) : is executable
                                       10       Group (W) : is writable
                                       11       Group (R) : is readable

                                       12       Other (D) : is delete protected
                                       13       Other (E) : is executable
                                       14       Other (W) : is writable
                                       15       Other (R) : is readable
                                    30-16       reserved
                                       31       SUID, MultiUserFS Only

BSIZE-188/-0xbc ulong   1       UNUSED          unused (== 0)
BSIZE-184/-0xb8 char    1       comm_len        comment length
BSIZE-183/-0xb7 char    79      comment[]       comment (max. 79 chars permitted)
BSIZE-104/-0x69 char    12      UNUSED          set to 0
BSIZE- 92/-0x5c ulong   1       days            last access date (days since 1 jan 78)
BSIZE- 88/-0x58 ulong   1       mins            last access time
BSIZE- 84/-0x54 ulong   1       ticks           in 1/50s of a seconds
BSIZE- 80/-0x50 char    1       name_len        hard link name length
BSIZE- 79/-0x4f char    30      hlname[]        hardlink name (max. 30 chars permitted)
BSIZE- 49/-0x31 char    1       UNUSED          set to 0
BSIZE- 48/-0x30 ulong   1       UNUSED          set to 0
BSIZE- 44/-0x2c ulong   1       real_entry      FFS : pointer to "real" file or directory
BSIZE- 40/-0x28 ulong   1       next_link       FFS : hardlinks chained list (first=newest)
BSIZE- 36/-0x24 ulong   5       UNUSED          set to 0
BSIZE- 16/-0x10 ulong   1       hash_chain      next entry ptr with same hash
BSIZE- 12/-0x0c ulong   1       parent          parent directory
BSIZE-  8/-0x08 ulong   1       UNUSED          set to 0
BSIZE-  4/-0x04 ulong   1       sec_type        secondary type : ST_LINKFILE = -4
                                                ST_LINKDIR = 4
------------------------------------------------------------------------------------------------
```

A 'real' entry is a file or directory entry, opposed to link entries.

A hard link can only be created to the same disk as the real entry disk. Several links can be made on the same real entry. These are in just another linked list.
'real entry' always contains the real entry block pointer.
'next_link' stores the links linked list.

New entries are added at the head:

```
>ls
  ------rw-d     1912  15-May-96 22:28:08  real
```

Chained list state :

```
block# real     next    name
----------------------------
484     0       0       real


>ln real link1
>ls
  ------rw-d     1912  15-May-96 22:28:08  real
  -H----rw-d     1912  15-May-96 22:28:10  link1 -> Empty:real

block# real     next    name
----------------------------
484     0       104     real
104     484     0       link1


>ln link1 link2
>ls
  ------rw-d     1912  15-May-96 22:28:08  real
  -H----rw-d     1912  15-May-96 22:28:10  link1 -> Empty:real
  -H----rw-d     1912  15-May-96 22:28:12  link2 -> Empty:real

block# real     next    name
----------------------------
484     0       107     real
104     484     0       link1
107     484     104     link2
```

The links are stored 'newest first', due to the adding at head.

real -> newest link -> ... -> oldest link -> 0

-> means "points to"

4.6.2 Soft links

```
* Soft link (BSIZE bytes)
----------------------------------------------------------------------------------------------
        0/ 0x00 ulong   1       type            block primary type = T_HEADER (value 2)
        4/ 0x04 ulong   1       header_key      self pointer
        8/ 0x08 ulong   3       UNUSED          unused (== 0)
       20/ 0x14 ulong   1       chksum          normal checksum algorithm
       24/ 0x18 ulong   *       symbolic_name   path name to referenced object, Cstring
                                                * = ((BSIZE - 224) - 1)
                                                for floppy disk: size= 288 - 1 chars
BSIZE-200/-0xc8 ulong   2       UNUSED          unused (== 0)
BSIZE-192/-0xc0 ulong   1       protect         protection flags (set to 0 by default)
```

```
                                          Bit     If set, means

                                             If MultiUser FileSystem : Owner
                                          0       delete forbidden (D)
                                          1       not executable (E)
                                          2       not writable (W)
                                          3       not readable (R)

                                          4       is archived (A)
                                          5       pure (reetrant safe), can be made resident (P)
                                          6       file is a script (Arexx or Shell) (S)
                                          7       Hold bit. if H+P (and R+E) are set the file
                                                   can be made resident on first load (OS 2.x an

                                          8       Group (D) : is delete protected
                                          9       Group (E) : is executable
                                         10       Group (W) : is writable
                                         11       Group (R) : is readable

                                         12       Other (D) : is delete protected
                                         13       Other (E) : is executable
                                         14       Other (W) : is writable
                                         15       Other (R) : is readable
                                      30-16       reserved
                                         31       SUID, MultiUserFS Only

BSIZE-188/-0xbc ulong   1       UNUSED          unused (== 0)
BSIZE-184/-0xb8 char    1       comm_len        comment length
BSIZE-183/-0xb7 char    79      comment[]       comment (max. 79 chars permitted)
BSIZE-104/-0x69 char    12      UNUSED          set to 0
BSIZE- 92/-0x5c ulong   1       days            last access date (days since 1 jan 78)
BSIZE- 88/-0x58 ulong   1       mins            last access time
BSIZE- 84/-0x54 ulong   1       ticks           in 1/50s of a seconds
BSIZE- 80/-0x50 char    1       name_len        soft link name length
BSIZE- 79/-0x4f char    30      slname[]        softlink name (max. 30 chars permitted)
BSIZE- 49/-0x31 char    1       UNUSED          set to 0
BSIZE- 48/-0x30 ulong   8       UNUSED          set to 0
BSIZE- 16/-0x10 ulong   1       hash_chain      next entry ptr with same hash
BSIZE- 12/-0x0c ulong   1       parent          parent directory
BSIZE-  8/-0x08 ulong   1       UNUSED          set to 0
BSIZE-  4/-0x04 ulong   1       sec_type        secondary type : ST_SOFTLINK = 3
-----------------------------------------------------------------------------------------------
```

4.7 How are the blocks associated with the directory cache mode ?

To speed up directory listing, Directory cache blocks have been created.
Directory cache blocks are also organised in chained lists.
The list starts at the directory block (root or normal directory) with the 'extension' field.

```
* Directory cache block (BSIZE bytes)
---------------------------------------------------------------------------
0/0     ulong   1       type            DIRCACHE == 33 (0x21)
4/4     ulong   1       header_key      self pointer
8/8     ulong   1       parent          parent directory
12/c    ulong   1       records_nb      directory entry records in this block
16/10   ulong   1       next_dirc       dir cache chained list
20/14   ulong   1       chksum          normal checksum
24/18   UCHAR   *       records[]       entries list (size = BSIZE-24)
---------------------------------------------------------------------------
```

The directory entries are stored this way :

```
* Directory cache block entry record (26 <= size (in bytes) <= 77)
-------------------------------------------------------------------------------
0       ulong   1       header          entry block pointer
                                        (the link block for a link)
4       ulong   1       size            file size (0 for a directory or a link)
8       ulong   1       protect         protection flags (0 for a link ?)
                                         (see file header or directory blocks)
12      ushort  1       UID             user ID
14      ushort  1       GID             group ID
16      short   1       days            date (always filled)
18      short   1       mins            time (always filled)
20      short   1       ticks
22      char    1       type            secondary type
23      char    1       name_len        1 <= len <= 30 (nl)
24      char    ?       name            name
24+nl   char    1       comm_len        0 <= len <= 22 (cl)
25+nl   char    ?       comment         comment
25+nl+cl char   1       OPTIONAL padding byte(680x0 longs must be word aligned)
-------------------------------------------------------------------------------
```

---

5. How does a blank disk look like ?

A minimal blank disk has a Bootblock, a Rootblock and a Bitmap block.

5.1 a Minimal blank floppy disk

```
* The Bootblock (0 and 1)

0       char    4       ID              'D''O''S' + flags
4       long    1023    full of zeros


* The Rootblock (880)

0       long    1       type            2
12/c    long    1       ht_size         0x48
20/14   long    1       checksum        computed
312/138 long    1       bm_flag         -1 (valid bitmap)
316/13c long    1       bm_pages[0]     bitmap sector #
420/1a4 long    1       last access date
424/1a8 long    1       last access time
428/1ac long    1       last access time
432/1b0 char    1       disk_name size
433/1b1 char    ?       disk_name
472/1d8 long    1       last access date
476/1dc long    1       last access time
480/1e0 long    1       last access time
484/1e4 long    1       creation date
488/1e8 long    1       creation time
492/1ec long    1       creation time
504/1f8 long    1       FFS : first dir cache sector  or 0
508/1fc long    1       sub_type        1

Unspecified fields are set to 0.


* The Bitmap block (here 881) for a DD disk

0       long    1       checksum
4       long    27      free sectors    0xffffffff
112/70  long    1       root+bitmap     0xffff3fff
```

```
116/74  long    27      free sectors    0xffffffff
120/78  long    72      unused          !=0
```

5.2 A 'Bootable' floppy disk

* The Bootblock becomes :

```
0/0x00  long    1       ID              'D''O''S' + flags
4/0x04  long    1       checksum        computed
8/0x08  long    1       rootblock ?     880
12/0x0c byte    81      bootcode        AmigaDOS 3.0 version

        values                  disassembled
        --------------+---------------------
        43FA003E                lea     exp(pc),a1      ;Lib name
        7025                    moveq   #37,d0          ;Lib version
        4EAEFDD8                jsr     -552(a6)        ;OpenLibrary()
        4A80                    tst.l   d0              ;error == 0
        670C                    beq.b   error1
        2240                    move.l  d0,a1           ;lib pointer
        08E90006 0022           bset    #6,34(a1)       ;(*)
        4EAEFE62                jsr     -414(a6)        ;CloseLibrary()
        43FA0018        error1: lea     dos(PC),a1      ;name
        4EAEFFA0                jsr     -96(a6)         ;FindResident()
        4A80                    tst.l   d0
        670A                    beq.b   error2          ;not found
        2040                    move.l  d0,a0
        20680016                move.l  22(a0),a0       ;DosInit sub
        7000                    moveq   #0,d0
        4E75                    rts
        70FF            error2: moveq   #-1,d0
        4E75                    rts
        646F732E 6C696272 617279
                        dos:    "dos.library"
        00                                              ;padding byte
        65787061 6E73696F 6E2E6C69 62726172 79
                        exp:    "expansion.library"

93/0x5d byte    931     full of zeros
```

(*) from Thomas Kessler (tkessler@ra.abo.fi), may 1997 :
This bit tells the shell (which opens its shell-window when booting the startup-sequence) not to open window unless needed, so a black screen stays there during boot instead of an empty shell-windows (it's a os2.x feature).

5.3 A Directory cache mode floppy disk

```
* A directory cache block (here 882)

0       long    1       type            0x21
4       long    1       self pointer    882
8       long    1       cached dir      880 (root)
12/c    long    1       entries number  0
16/10   long    1       next dir cache  0 (last)
20/14   long    1       checksum        computed
24      long    122     full of zeros
```

5.4 International Mode

The toupper() function in the HashName() function (3.2.1 paragraph) is replaced by the following function with the aim of better handling international characters :

```
int intl_toupper(int c)
{
   return (c>='a' && c<='z') || (c>=224 && c<=254 && c!=247) ? c - ('a'-'A') : c ;
}
```

In the Amiga ASCII table, the international character codes are between 192 and 254. Uppercase caracters are between 192 and 222, the lowercase versions of them are between 224 and 254. The only exception are the codes 215 and 247, which are respectively the multiply sign and the divide sign.

The Amiga character set is the same as ISO 8859 Latin-1 character set, often assumed in HTML pages. This character set is described here : http://www.w3c.org/

---

6. The structure of a hard disk

The following structures are mainly extracted from the 'devices/hardblocks.h' and 'dos/filehandler.h' files delivered in Commodore developer kits.

The hard disk specific structures mainly store the drive geometry, the written partitions sizes and the filesystem bootcode.

The five kind of blocks are in a reserved area, at the beginning of the surface. The first of them, Rigid Disk block (RDSK), must be found within the first 16 blocks of BSIZE lenght. But it can be written inside the data area, which is dangerous.

6.1 What is the Rigid Disk Block ?

```
* Rigid Disk block (256 bytes) must exist within the first 16 blocks
------------------------------------------------------------------------------------
0/0     char    4       id                'RDSK'
4/4     ulong   1       size in longs     == 64
8/8     long    1       checksum          classic Rootblock algorithm
12/c    ulong   1       hostID            SCSI Target ID of host
                                          (== 7 for IDE and ZIP disks)
16/10   ulong   1       block size        typically 512 bytes, but can
                                          be other powers of 2
20/14   ulong   1       flags             typically 0x17
                                Bit       If set means :
                                0         No disks exists to be configured
                                          after this one on this controller
                                1         No LUNs exists to be configured greater
                                          than this one at this SCSI Target ID
                                2         No target IDs exists to be configured
                                          greater than this one on this SCSI bus
                                3         Don't bother trying to perform
                                          reselection when talking to this drive
                                4         Disk indentification valid
                                5         Controller indentification valid
                                6         Drive supports SCSI synchronous mode
                                          (can be dangerous if it doesn't)
24/18   ulong   1       Bad blockList     block pointer (-1 means last block)
28/1c   ulong   1       PartitionList     block pointer (-1 means last)
32/20   ulong   1       FileSysHdrList    block pointer (-1 means last)
36/24   ulong   1       DriveInit code    optional drive-specific init code
                                          DriveInit(lun,rdb,ior) :
```

```
                                         "C" stack and d0/a0/a1
40/28   ulong   6       RESERVED         == -1

        Physical drive caracteristics
64/40   ulong   1       cylinders        number of drive cylinder
68/44   ulong   1       sectors          sectors per track
72/48   ulong   1       heads            number of drive heads
76/4c   ulong   1       interleave
80/50   ulong   1       parking zone     landing zone cylinders
                                         soon after the last cylinder
84/54   ulong   3       RESERVED         == 0
96/60   ulong   1       WritePreComp     starting cyl : write precompensation
100/64  ulong   1       ReducedWrite     starting cyl : reduced write current
104/68  ulong   1       StepRate         drive step rate
108/6c  ulong   5       RESERVED         == 0

        Logical drive caracteristics
128/80  ulong   1       RDB_BlockLo      low block of range reserved for hardblk
132/84  ulong   1       RDB_BlockHi      high block of range for this hardblocks
136/88  ulong   1       LoCylinder       low cylinder of partitionable disk area
140/8c  ulong   1       HiCylinder       high cylinder of partitionable data area
144/90  ulong   1       CylBlocks        number of blocks available per cylinder
148/94  ulong   1       AutoParkSeconds zero for no autopark
152/98  ulong   1       HighRSDKBlock    highest block used by RDSK
                                         (not including replacement bad blocks)
156/9c  ulong   1       RESERVED         == 0

        Drive identification
160/a0  char    8       DiskVendor       ie 'IOMEGA'
168/a8  char    16      DiskProduct      ie 'ZIP 100'
184/b8  char    4       DiskRevision     ie 'R.41'
188/bc  char    8       ControllerVendor
196/c4  char    16      ControllerProduct
212/d4  char    4       ControllerRevision
216/d8  ulong   10      RESERVED         == 0
256/100
--------------------------------------------------------------------------------
```

*** How to find the physical geometry of the disk ?**

A hard disk is made of several physical disks. They have one head for each writable side. Each physical disk consists of several tracks, which consist of several sectors. One cylinder is the set of the tracks which have the same number on each disk.

The total size of the hard disk is expressed in cylinders ('cylinders').
The size of a cylinder is :
the number of heads per cylinder ('heads')
x the number of sectors per track ('sectors')
x the size of a block ('block size').

The 'CylBlocks' field equals to 'heads' x 'sectors'.

The reserved area is often the 2 first cylinders, between the 'RDB_BlockLo' block and the 'RDB_BlockHi' block, included. The partitionable area, starts at the 'LoCylinder' cylinder until the 'HiCylinder' cylinder, included.

The really last used sector in the reserved area is the sector numbered 'HighRSDKBlock', the first is numbered 0. The SCSI 'hostID' is set to the id of the SCSI host controller, which is typically 7. Real SCSI drives ID must be between 0 and 6.

The RDSK block is the "root" of the reserved area. It also contains the first blocks of three linked lists : one the bad blocks replacement, one for the partition definitions and one last for the filesystem information.

Some geometry examples :

- a Zip disk : 2891 cylinders, 1 head, 68 sectors,
- my 80Mb Seagate IDE harddisk : 980 cylinders, 10 heads, 17 sectors.
- a 500 Mbyte Fujitsu 2624SA: 1472 cylinders, 11 heads, 63 sectors
- a 50 Mbyte Quantum LPS52: 2085 cylinders, 1 head, 49 sectors

---

6.2 How are bad blocks managed ?

```
* Bad Block block (BSIZE bytes) first in RDSK 'BadBlockList' field
------------------------------------------------------------------------------
0/0     ulong   1       id              'BADB'
4/4     ulong   1       size in longs   == 128 for BSIZE = 512
8/8     long    1       checksum
12/c    ulong   1       HostID          == 7 ?
16/10   ulong   1       next            next BadBlock block
20/14   ulong   1       RESERVED
24/18           *       BlockPairs[]    bad block entries table
                                        * size = ((BSIZE/4)-6)/2
                                        (for BSIZE=512 = 61*8 byte entries)
------------------------------------------------------------------------------

* Bad Block entry (8 bytes) stored in BadBlock 'BlockPairs[]' field
------------------------------------------------------------------------------
0/0     ulong   1       BadBlock        block number of bad block
4/4     ulong   1       GoodBlock       block number of replacement block
------------------------------------------------------------------------------
```

6.3 How are partitions stored?

```
* Partition block (256 bytes) first in RDSK 'PartitionList' field
------------------------------------------------------------------------------
0/0     char    4       ID              'PART'
4/4     ulong   1       size in long    of checksummed structure (== 64)
8/8     ulong   1       checksum        classic algorithm
12/c    ulong   1       hostID          SCSI Target ID of host (== 7)
16/10   ulong   1       next            block number of the next Partitionblock
20/14   ulong   1       Flags
                                Bit     If set means
                                0       This partition is bootable
                                1       No automount
24/18   ulong   2       RESERVED
32/20   ulong   1       DevFlags        preferred flags for OpenDevice
36/24   char    1       DriveName len   length of Drive name (e.g. 3)
37/25   char    31      DriveName       e.g. 'DH0'
68/44   ulong   15      RESERVED

        DOS Environment vector (DOSEnvVec) (often defined in MountLists)
128/80  ulong   1       size of vector  == 16 (longs), 11 is the minimal value
132/84  ulong   1       SizeBlock       size of the blocks in longs ==
                                        128 for BSIZE = 512
136/88  ulong   1       SecOrg          == 0
140/8c  ulong   1       Surfaces        number of heads (surfaces) of drive
144/90  ulong   1       sectors/block   sectors per block == 1
148/94  ulong   1       blocks/track    blocks per track
152/98  ulong   1       Reserved        DOS reserved blocks at start of partition
```

```
                                        usually = 2 (minimum 1)
156/9c  ulong   1       PreAlloc        DOS reserved blocks at end of partition
                                        (no impact on Root block allocation)
                                        normally set to == 0
160/a0  ulong   1       Interleave      == 0
164/a4  ulong   1       LowCyl          first cylinder of a partition (inclusive)
168/a8  ulong   1       HighCyl         last cylinder of a partition (inclusive)
172/ac  ulong   1       NumBuffer       often 30 (used for buffering)
176/b0  ulong   1       BufMemType      type of mem to allocate for buffers ==0
180/b4  ulong   1       MaxTransfer     max number of type to transfer at a type
                                        often 0x7fff ffff
184/b8  ulong   1       Mask            Address mask to block out certain memory
                                        often 0xffff fffe
188/bc  ulong   1       BootPri         boot priority for autoboot
192/c0  char    4       DosType         'DOS' and the FFS/OFS flag only
                                        also 'UNI'\0 = AT&T SysV filesystem
                                        'UNI'\1 = UNIX boot filesystem
                                        'UNI'\2 = BSD filesystem for SysV
                                        'resv' = reserved (swap space)
196/c4  ulong   1       Baud            Define default baud rate for Commodore's
                                        SER and AUX handlers, originally
                                        used with the A2232 multiserial board
200/c8  ulong   1       Control         used by Commodore's AUX handler
204/cc  ulong   1       Bootblocks      Kickstart 2.0: number of blocks
                                        containing boot code to be
                                        loaded at startup
208/d0  ulong   12      RESERVED
------------------------------------------------------------------------------
```

There exists one 'PART' block per partition.

The block pointers in the reserved area are relative to the beginning of the media. The block pointers in a partition are relative to the first block of the partition.

The Rootblock of a partition is normally located in the middle of an AmigaDOS filesystem. Please see 4.2 What is a Rootblock? for the exact calculation of it's location.

The first two blocks of a partition contain a Bootblock. You have to use it to determine the correct file system, and if the international or dircache modes are used. Don't rely only on the PART and FSHD 'DosType' field.

6.4 What are FSHD blocks ?

```
* Filesystem header block (256 bytes) first in RSDK 'FileSysHeaderList'
------------------------------------------------------------------------------
0/0     char    4       id              'FSHD'
4/4     ulong   1       size in longs   == 64
8/8     long    1       checksum        classic algorithm
12/c    ulong   1       hostID          SCSI Target ID of host (often 7)
16/10   ulong   1       next            block number of next FileSysHeaderBlock
20/14   ulong   1       flags
24/18   ulong   2       RESERVED
32/20   char    4       DosType         'DOS' and OFS/FFS DIRCACHE INTL bits
36/24   ulong   1       Version         filesystem version 0x0027001b == 39.27
40/28   ulong   1       PatchFlags      bits set for those of the following
                                        that need to be substituted into a
                                        standard device node for this
                                        filesystem : e.g. 0x180 to substitute
                                        SegList and GlobalVec
        Device node
44/2c   ulong   1       Type            device node type == 0
48/30   ulong   1       Task            standard DOS "task" field == 0
```

```
52/34   ulong   1       Lock            not used == 0
56/38   ulong   1       Handler         filename to loadseg == 0
60/3c   ulong   1       StackSize       stacksize to use when starting task ==0
64/40   ulong   1       Priority        task priority when starting task == 0
68/44   ulong   1       Startup         startup msg == 0
72/48   ulong   1       SegListBlock    first of linked list of LoadSegBlocks :
                                        note that this entry requires some
                                        processing before substitution
76/4c   ulong   1       GlobalVec       BCPL global vector when starting task =-1
80/50   ulong   23      RESERVED        by PatchFlags
172/ac  ulong   21      RESERVED
--------------------------------------------------------------------------------
```

This block contains information on how to lauch the task which will manage the filesystem. You don't need it to reach partitions.

6.5 What are LSEG blocks ?

```
* LoadSeg block (BSIZE bytes) first in FileSysHeaderBlock 'SegListBlocks' field
--------------------------------------------------------------------------------
0/0     char    4       id              'LSEG'
4/4     long    *       size in longs   size of this checksummed structure
                                        * size = BSIZE/4
8/8     long    1       checksum        classic checksum
12/c    long    1       hostID          SCSI Target ID of host (often 7)
16/10   long    1       next            block number of the next LoadSegBlock
                                        (-1 for the last)
20/14   uchar   *       LoadData[]      code stored like an executable, with
                                        relocation hunks
                                        * size = ((BSIZE/4) - 5)
--------------------------------------------------------------------------------
```

This block contains the code of the filesystem. It isn't needed to reach partitions.

---

7. The Hard file : a big floppy dump file

A hardfile is a file which contains an Amiga volume.

It is created with WinUAE (http://www.winuae.net/), and not the Amiga and the AmigaDOS. WinUAE is able to produce an empty file with random contents of a choosen size, often several megabytes long.
Under WinUAE, a AmigaDOS device appears, associated with the uaehf.device (UAE hardfile). You have to format it with the Workbench, and you obtain an 'hardfile'. This volume is then usable inside the emulator by AmigaDOS (it should also be mountable under Linux with the AFFS filesystem).

For example a 8Mb hardfile could be mounted on a kickstart 1.3 Amiga with the following mountlist (from uae docs/README) :

```
UAE0:  Device = uaehf.device
           Unit   = 0
           Flags  = 0
           Surfaces  = 1
           BlocksPerTrack = 32
           Reserved = 1
           Interleave = 0
           LowCyl = 0  ;  HighCyl = 511
           Buffers = 5
           DosType = 0x444F5300
           BufMemType = 1
```

An hardfile is like a floppy disk dump, but bigger : it has a bootblock, a rootblock, a bitmap and perhaps dircache blocks.
The first three bytes of a hardfile is then 'D' 'O' 'S'.

The geometry is : heads = 1, sectors = 32, 'cylinders' depends the hardfile size.

---

8. Advanced information

Bitmap related

* Bitmap allocation starts at root block, upto highest block. The next allocated blocks are located just after boot blocks and finally the last allocated block is the sector before root block.

root -> max -> boot+1 -> root-1

-> means "followed on disk by"

If you free some blocks by deleting a file, for example, the first next used block will be the first free block encountered starting from the Rootblock. The just freed blocks will be reused. It means that when you delete a file and you want to recover it, don't write anything else to the disk.
This strategy must have been chosen to minimize fragmentation.

Files related

* The order in which data and file extension blocks for a given file are written on disk differs with OFS and FFS.

- OFS & FFS : All the data blocks of the file header block are written first.
- FFS : Then follow all the file extension blocks of the file, then all the remaining data blocks are written.
  OFS : Each file extension block is followed by the related data blocks. So the last extension block is followed by the remaining data blocks.

OFS:
header -> data blocks -> ext. block -> data blocks -> ext. block -> data blocks

FFS:
header -> data blocks -> all ext. block -> all remaining data blocks

-> means "followed on disk by"

This difference is probably the main reason why FFS is faster then OFS.

Under FFS, the hash chains are sorted by block number.

Comparison chart of the ADF logical blocks

```
                              root   dir    fileh    hlink    slink    fext     data     dirc
-----------------------------------------------------------------------------------------------
        0/ 0x00 1st_type      2      2      2        2        2        16       8        33
        4/ 0x04 header_key    /      x      x        x        x        x        x        x
```

```
        8/ 0x08             /      /      nb_blo  /       /       nb_blo  block#  PARENT
       12/ 0x0c table_size  72     /      /       /       /       /       nb_data nb_rec
       16/ 0x10 list        /      /      data#1  /       /       /       next    next
       20/ 0x14 chksum      x      x      x       x       x       x       x       x
       24/ 0x18 table       ht     ht     blocks  /       /       blocks  data    records
    ...
BSIZE-184/-0xb8 comment_len /      x      x       /       /       /       /       /
BSIZE-183/-0xb7 comment     /      x      x       /       /       /       /       /
    ...
BSIZE- 92/-0x5c days        x      x      x       x       x       /       /       /
BSIZE- 88/-0x58 mins        x      x      x       x       x       /       /       /
BSIZE- 84/-0x54 ticks       x      x      x       x       x       /       /       /
BSIZE- 80/-0x50 name_len    x      x      x       x       x       /       /       /
BSIZE- 79/-0x4f name        x      x      x       x       x       /       /       /
    ...
BSIZE- 16/-0x10 hash_chain  /      x      x                       /       /       /
BSIZE- 12/-0x0c parent      /      x      x       x       x       fhdr    /       /
BSIZE-  8/-0x08 extension   cache  cache  fext    /       /       next    /       /
BSIZE-  4/-0x04 2nd_type    1      2      -3      -4/4    3       -3      /       /
------------------------------------------------------------------------------------------

type of blocks :
 root=rootblock,  dir=directory,  fileh=file header,  fext=file extension,
 hlink=hard link,  slink=soft link,  dirc=directory cache,  data=OFS data.

special values :
 /=unused
 x=used
 next=next block of same type
```

How to rename an entry ?

1. Compute the new hashvalue
2. Move the first sector pointer from the old hashvalue index to the new one
3. Change the name in the directory or file header block

---

9. References and links

* ASM Sources:

- Scoopex and Crionics disassembled demo hardloaders
- 'the floppy disk book' copier source file, DATA BECKER books, 1988

* On-Line material :

- Very good 'ded.doc' file including Hard Disk information : ftp://ftp.funet.fi/pub/amiga/utilities/disk/Ded-1.11.lha
- A clean track-loader which doesn't use AmigaDOS (by Patrik Lundquist, newer version) : http://aminet.net/package/dev/src/trackldr1_43
- A replacement for 'trackdisk.device' : http://aminet.net/package/disk/misc/hackdisk202
- 'amigadisk_hardware.doc' (by Dave Edwards, Mark Meany, ... of ACC) : http://home.sol.no/svjohan/assem/refs/diskHW.lha
- DiskMonTools, a very good MFM/filesystem disk monitor for the Amiga : ftp://uk.aminet.net/pub/aminet/disk/moni/DiskMonTools.lha

* Books :

- The Amiga Guru Book, Chapter 15, Ralph Babel, 1993
- Rom Kernel Reference Manual : Hardware, pages 235-244, Addison Wesley
- Rom Kernel Reference Manual : Libraries and Devices, Appendix C, Addison Wesley
- La Bible de l'Amiga, Dittrich/Gelfand/Schemmel, Data Becker, 1988.

The AmigaDOS reference manual probably contains a lot of information about Amiga file systems, but i don't own it (Addison Wesley). The most detailed information about AmigaDOS can be found in Ralph Babel's "Amiga Guru Book".

---

10. C routines : the ADF library

The ADFlib is a portable C library designed to manage Amiga formatted devices like harddisks and ZIP disks, or dump files of this kind of media via the .ADF format.

The API permits you to :

- mount/unmount a device (real one or a dump file),
- mount/unmount a volume (partition),
- create/open/close/delete/move/undelete a file,
- read/write bytes from/to a file,
- create/delete/undelete a directory,
- get directory contents, change current directory, get parent directory.

A callback system makes it easy to write a real device driver for any platform. The **ADFOpus** (http://adfopus.sourceforge.net/) application (a useful Windows Explorer like for ADF files and devices), written by Dan Sutherlan is able to access from NT4 an 2.5 inches harddisk formatted under AmigaDOS.
The **ADFView** Windows Explorer shell extension (http://www.viksoe.dk/code/adfview.htm) written by Bjarke Viksoe is also using ADFlib. Hard-disks under W2000 are also supported.

See the 1.2 section to see how to obtain the package.

---

11. Other Amiga FileSystems

- An Amiga filesystem for Linux 0.99pl2 by Ray Burr (read only, hard disk): ftp://tsx-11.mit.edu/pub/linux/patches/amigaffs.tar.Z
- The AFFS filesystem inside the Linux kernel distribution by Hans-Joachim "JBHR" Widmaier (RDSK, links and international mode supported, dircache disks read-only): ftp://ftp.us.kernel.org in /usr/src/linux/fs/affs/
  Currently maintained by Roman Zippel (zippel@linux-m68k.org)
- An .ADF manipulation package for DOS/Windows, "ADF-suite" (GUI, Shareware, no sources included): link broken

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The .ADF format FAQ ends here !