DVD and CDR formats and how to use them

Or CDR, CDRW, DVD-R, RW,R+, R- What do they mean and why do I need them?

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CCS NW Chapter
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What is a CD?

• CD – as in Music CDs are not ‘burned’ but pressed from glass masters.
• CDR – Compact Disc Recordable are ‘burned’ with a laser to create a compatible media. Has a grooved track to guide the laser to burn the disk.
What is in a CDR?

• Your basic CD-R is layered like this, from top to bottom:
  - [optional] label
  - [optional] scratch-resistant and/or printable coating
  - UV-cured lacquer
  - Reflective layer (24K gold or a silver alloy)
  - Organic polymer dye
  - Polycarbonate substrate (the clear plastic part)

• Yes, it's real gold in "green" and "gold" CDs, but if you hold a CD-R up to a light source you'll notice that it's thin enough to see through (the gold layer is between 50 and 100nm thick). Something to bear in mind is that the data is closest to the label side of the CD, not the clear plastic side that the data is read from. If the CD-R doesn't have a hard top coating such as Kodak's "Infoguard", it's fairly easy to scratch the top surface and render the CD-R unusable.
How does a CD/CDR encode data?

• Information is recorded on spiral tracks around the disk with encoding of data in Lands and pits (CD). Write once CDR use a dye that changes color when written by the laser which records ‘marks’ similar to the Lands and Pits..
What’s in a CD-RW?

- The construction of a CD-RW is different:
  - [optional] label
  - [optional] scratch-resistant and/or printable coating
  - UV-cured lacquer
  - Reflective layer (aluminum)
  - Upper dielectric layer
  - Recording layer (phase change film, i.e. the part that changes form)
  - Lower dielectric layer
  - Polycarbonate substrate (the clear plastic part)
What are the different standards for CDs?

- **Red Book**
  - physical format for audio CDs (a/k/a CD-DA)

- **Yellow Book**
  - physical format for data CDs

- **Green Book**
  - physical format for CD-i

- **Orange Book**
  - physical format for recordable CDs
    - **Part I**
      - CD-MO (Magneto-Optical)
    - **Part II**
      - CD-WO (Write-Once; includes "hybrid" spec for PhotoCD)
    - **Part III**
      - CD-RW (ReWritable; originally called CD-E)
What are the different standards for CDs (part 2)?

- **White Book**
  - format for VideoCD (often written "VCD")
- **Blue Book**
  - CD Extra (occasionally used to refer to LaserDisc format)
- **CD Extra**
  - a two-session CD, 1st is CD-DA, 2nd is data (a/k/a CD Plus)
- **MODE-1**
  - standard 2048-byte Yellow Book sectors, with error correction
- **MODE-2**
  - 2336-byte sectors, usually used for CD-ROM/XA
- **CD-ROM/XA**
  - eXtended Architecture; CD-ROM/XA MODE-2 defines two forms:
    - **FORM-1**
      - 2048 bytes of data, with error correction, for data
    - **FORM-2**
      - 2324 bytes of data, no ecc, for audio/video
What are the different standards for CDs (part 3)?

- **ISO-9660**
  - file layout standard (evolved from High Sierra format)
- **Rock Ridge**
  - extensions allowing long filenames and UNIX-style symlinks
- **CD-RFS**
  - Sony's incremental packet-writing filesystem
- **CD-UDF**
  - industry-standard incremental packet-writing filesystem
- **CD-Text**
  - Philips' std for encoding disc and track data on audio CDs
- **CD-ROM/XA** is an extension to the Yellow Book Mode 2 standard. It was intended as a bridge between CD-ROM and CD-i (Green Book).
Whew, that’s a lot of standards! How can you tell what format a disk is in???

- You can usually tell by looking at the packaging and/or the disc itself:
  - CD-DA discs will have a "Compact Disc Digital Audio" logo.
  - CD+G discs will have the words "CD Graphics" (and perhaps even CD-EG "Extended Graphics").
  - CD-i discs will have a "Compact Disc Interactive" logo.
  - VideoCD discs will have a "Compact Disc Digital Video" logo and/or the words "VideoCD".
  - PhotoCD discs will most likely say "Kodak PhotoCD" on them.
  - SVCD discs have a "Super Video CD" logo (the words "Super Video" under the standard CD logo). The discs use one of the standard CD-ROM formats.
  - DVCD discs say "DVCD"??
  - HDCD (High Definition Compatible Digital) have an "HDCD" logo. See http://www.hdcd.com/. The discs appear to use the standard Red Book format.
  - SACD (Super Audio Compact Disc) is relatively new. The discs can have two layers, one of which is in Red Book audio format, the other in a DVD-like format offering higher fidelity.
  - DTS (Digital Theater Surround) CDs are just like normal CDs, but use DTS encoding instead of PCM. See (2-34).
  - VideoCD is different from CD-Video (a/k/a "Compact Disc Video", or CD-V). CD-V is an analog format, like LaserDisc, and the video can't be viewed with a CD-ROM drive.
What are the different formats for Audio CDs and Data CDs?

- **CDDA** – Compact Disk Digital Audio – about 330,000 blocks of 2K bytes. (each block = about 13ms.. 75 blocks/sec)
- An audio “Track” is identified by a starting block and a length.
- Difference between TAO – Track at Once, DAO Disk at Once. The laser is turned off for 2 seconds after a track is written.
- A session is a recorded segment of ‘tracks’ which are a “starting Block’ + number of Blocks (minimum 300) collected together.
- The CD recorder doesn't have to write the entire session at once -- you can write a single track, and come back later and write another -- but the session must be "closed" before a standard audio CD or CD-ROM player will be able to use it. Additional sessions can be added until the *disc* is closed or there's no space left.
What are the different formats for Audio CDs and Data CDs Part 2?

• Multisession writing was first used on PhotoCD discs, to allow additional pictures to be appended. Today it's most often used with "linked" multisession discs, and occasionally for CD-Extra discs. These require a bit more explanation.

• When you put a data CD into your CD-ROM drive, the OS finds the last closed session on the disc and reads the directory from it. (Well, that's how it's supposed to work. Depending on your operating system and CD-ROM drive, you may get different results.) If the CD was written in ISO-9660 format -- most store-bought CD-ROMs are -- the directory entries can point at any file on the CD, no matter which session it was written in.
What are the different formats for Audio CDs and Data CDs Part 3?

• In contrast, when you put an audio CD into a typical CD player, it only looks at the first session. For this reason, multisession writes don't work for audio CDs, but as it happens this limitation can be turned into an advantage.. This limitation does *not* mean you have to write an entire audio CD all at once;

• (Some audio CD players do seem to be able to recognize all of the tracks on a multisession audio disc. Most do not. The only way to know for sure is to try and see. If you are planning to give an audio CD you create to others, it would be wise to write it in a single session.)
How does CDRW compare to CDR?

- CD-RW is short for CD-Rewritable. It used to be called CD-Erasable (CD-E), but some marketing folks changed it so it wouldn't sound like your important data gets erased on a whim. The difference between CD-RW and CD-R is that CD-RW discs can be erased and rewritten, while CD-R discs are write-once. Other than that, they are used just like CD-R discs.

- Let me emphasize that: they are used just like CD-R discs. You can use packet writing on both CD-R and CD-RW, and you can use disc-at-once audio recording on both CD-R and CD-RW. Some software may handle CD-RW in a slightly different way, because you can do things like erase individual files, but the recorder technology is nearly identical.

- CD-RW drives use phase-change technology. Instead of creating "bubbles" and deformations in the recording dye layer, the state of material in the recording layer changes from crystalline to amorphous form. The different states have different refractive indices, and so can be optically distinguished.
How does CDRW compare to CDR Part 2?

• These discs are not writable by standard CD-R drives, nor readable by most older CD readers (the reflectivity of CD-RW is far below CD and CD-R, so an Automatic Gain Control circuit is needed to compensate). Most new CD-ROM drives do support CD-RW media, but not all of them will read CD-RW discs at full speed.

• A few older audio CD players and many new ones can handle CD-RW discs, but many can't. If you want to create audio CDs on CD-RW media, make sure that your player can handle them.

• All CD-RW recorders can write to CD-R media, so the only reason not to buy a CD-RW recorder is price. Some Internet sites like to put the devices in completely separate categories, calling them "CD recorders" and "CD ReWriters", but the differences between them don't really merit such a distinction. Think of a "CD ReWriter" as a CD recorder that can also make use of CD-RW media.

• Oddly enough, it may be easier for a DVD drive to read CD-RW discs than CD-R discs, because of the way the media is constructed.

• CD-RW media is more expensive than CD-R, but recent price reductions have narrowed the gap considerably. There is a limit to the number of times an area of the disc can be rewritten, but that number is relatively high (the Orange Book requires 1000, but some manufacturers have claimed as much as 100,000). Of course, this is under laboratory conditions. If you don't handle the disc carefully, you will add scratches, dirt, fingerprints, and other obstacles that make the disc harder for the drive to read.
How does CDRW compare to CDR (part 3)?

- It appears that CD-RW discs have speed ratings encoded on them, so discs that are only certified for 2x recording can't be written to at 4x (or, for that matter, 1x). To make things more complicated, different media is required for high-speed CD-RW drives (those that exceed 4x).

- **So, does that mean I can burn a CDRW instead of a CDR?**
  - Almost. The CDRW will usually take longer to burn than a CDR. Instead of 48X you may be burning at 4x.
  - But, you can burn it again and again..
  - **Caveat.** Not all CDROM drives can read CDRW. Newer ones can, but older ones may have problems due to the reflectivity of the media.
What is a DVD?

- Digital Versatile Disk. It looks like a CD, but has much larger capacity.
- First DVD players hit the market in March, 1997
- Differences?

<table>
<thead>
<tr>
<th>Specification</th>
<th>CD</th>
<th>DVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track Pitch</td>
<td>1600 nanometers</td>
<td>740 nanometers</td>
</tr>
<tr>
<td>Minimum Pit Length (single-layer DVD)</td>
<td>830 nanometers</td>
<td>400 nanometers</td>
</tr>
<tr>
<td>Minimum Pit Length (double-layer DVD)</td>
<td>830 nanometers</td>
<td>440 nanometers</td>
</tr>
</tbody>
</table>
What is are the layers of a DVD?

- **Single-sided, single layer (4.7GB)**

- **Single-sided, double layer (8.5GB)**

- **Double-sided, double layer (17GB)**
DVD Formats de jour

- **DVD**
  - Movies pressed like CDs.
  - Readers: Early units couldn’t read CD-ROMs. Units with “Dual Optics” can read the differently spaced tracks.
  - Most newer DVD-ROM drives can read CDs.

- **DVD-R**
  - Originally was DVD-R(A) – Authoring and DVR-R(G) General.
  - Both used organic Dye for the recording media but DVR-R(A) used a 635nm laser while the DVD-R(G) used a cheaper 650nm laser (same as DVD-RAM). 4.7Gb storage capacity. DVD-R(A) recording systems originally cost $17000 while DVR-R(G) drives originally cost under $1000. Each uses a different media, but both can read each other’s media. (can’t write it though.)

- **DVD-RW**
  - DVD-RW (formerly DVD-R/W and also briefly known as DVD-ER) is a phase-change erasable format. DVD-RW drives write DVD-R, DVD-RW, CD-R, and CD-RW discs.
• DVD-RAM
  – DVD-RAM, with an initial storage capacity of 2.58 billion bytes, later increased to 4.7, uses phase-change dual (PD) technology with some magneto-optic (MO) features mixed in. DVD-RAM is the best suited of the writable DVD formats for use in computers, because of its defect management and zoned CLV format for rapid access. However, it's not compatible with most drives and players (because of defect management, reflectivity differences, and minor format differences). A wobbled groove is used to provide clocking data, with marks written in both the groove and the land between grooves. The grooves and pre-embossed sector headers are molded into the disc during manufacturing. Single-sided DVD-RAM discs come with or without cartridges. There are two types of cartridges: type 1 is sealed, type 2 allows the disc to be removed. Discs can only be written while in the cartridge. Double-sided DVD-RAM discs were initially available in sealed cartridges only, but now come in removable versions as well.
• DVD+RW and DVD+R
  - DVD+RW is an erasable format based on CD-RW technology. It became available in late 2001. DVD+RW is supported by Philips, Sony, Hewlett-Packard, Dell, Ricoh, Yamaha, and others. It is not supported by the DVD Forum (even though most of the DVD+RW companies are members), but the Forum has no power to set standards. DVD+RW drives read DVD-ROMs and CDs, and usually read DVD-Rs and DVD-RWs, but do not read or write DVD-RAM discs. DVD+RW drives also write CD-Rs and CD-RWs. DVD+RW discs, which hold 4.7 billion bytes per side, are readable in many existing DVD-Video players and DVD-ROM drives. (They run into the same reflectivity and disc format recognition problems as DVD-RW.)
Why can’t I print a screen snapshot of a movie running on my PC?
Movies are encoded with MPEG 2 and/or MPEG 4. Most DVD PCs, even those with software decoders, use video overlay hardware to insert the video directly into the VGA signal. This an efficient way to handle the very high bandwidth of full-motion video.

Why can’t I play a movie saved to my hard drive?
Almost all movies are encrypted with CSS copy protection. Decryption keys are stored in the normally inaccessible lead-in area of the disc. You'll usually get an error if you try to copy the contents of an encrypted DVD to a hard drive. However, if you have used a software player to play the movie it will have authenticated the disc in the drive, allowing you to copy without error, but the encryption keys will not be copied. If you try to play the copied VOB files, the decoder will request the keys from the DVD-ROM drive and will fail. You may get the message "Cannot play copy-protected files".
# DVD Formats – So what reads what?

<table>
<thead>
<tr>
<th>Disc Type</th>
<th>DVD Unit</th>
<th>DVD-R(G) Unit</th>
<th>DVD-R(A) Unit</th>
<th>DVD-RW Unit</th>
<th>DVD-RAM Unit</th>
<th>DVD+RW Unit</th>
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</thead>
<tbody>
<tr>
<td>DVD-ROM disc</td>
<td>reads</td>
<td>reads</td>
<td>reads</td>
<td>reads</td>
<td>reads</td>
<td>reads</td>
</tr>
<tr>
<td>DVD-R(G) disc</td>
<td>often reads</td>
<td>reads, writes</td>
<td>reads</td>
<td>reads, writes</td>
<td>reads</td>
<td>reads</td>
</tr>
<tr>
<td>DVD-R(A) disc</td>
<td>usually reads</td>
<td>reads, writes</td>
<td>reads</td>
<td>reads</td>
<td>reads</td>
<td>reads</td>
</tr>
<tr>
<td>DVD-RW disc</td>
<td>often reads</td>
<td>reads</td>
<td>reads</td>
<td>reads, writes</td>
<td>usually reads</td>
<td>usually reads</td>
</tr>
<tr>
<td>DVD-RAM disc</td>
<td>rarely reads</td>
<td>doesn't read</td>
<td>doesn't read</td>
<td>doesn't read</td>
<td>reads, writes</td>
<td>doesn't read</td>
</tr>
<tr>
<td>DVD+RW disc</td>
<td>usually reads</td>
<td>usually reads</td>
<td>usually reads</td>
<td>usually reads</td>
<td>usually reads</td>
<td>reads, writes</td>
</tr>
<tr>
<td>DVD+R disc</td>
<td>often reads</td>
<td>usually reads</td>
<td>usually reads</td>
<td>usually reads</td>
<td>reads</td>
<td>reads, may write</td>
</tr>
<tr>
<td>Format</td>
<td>Backers</td>
<td>Data depth</td>
<td>Laser</td>
<td>Video</td>
<td>Capacity (single layer/dual layer)</td>
<td>Data rate</td>
</tr>
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<tr>
<td>HD-DVD</td>
<td>DVD Forum</td>
<td>0.6 mm</td>
<td>Blue (405 nm)</td>
<td>HD MPEG-2, H.264, VC9*</td>
<td>15G / 30G (ROM), 20G / 40G (recordable)</td>
<td>36 Mbps</td>
</tr>
<tr>
<td>Blu-ray</td>
<td>Blu-Ray Disc Founders</td>
<td>0.1 mm</td>
<td>Blue (405 nm)</td>
<td>HD MPEG-2</td>
<td>27G / 50G</td>
<td>36 Mbps</td>
</tr>
<tr>
<td>EVD</td>
<td>eWorld (Govt. of China)</td>
<td>0.6 mm</td>
<td>Red (650 nm)</td>
<td>HD MPEG-2 (later AVC)</td>
<td>na / 8.5G (ROM)</td>
<td>22 Mbps</td>
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<tr>
<td>FVD 1</td>
<td>ITRI (Taiwan)</td>
<td>0.6 mm</td>
<td>Blue (405 nm)</td>
<td>AVC</td>
<td>17G / na</td>
<td>25.05 Mbps</td>
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<tr>
<td>FVD 2</td>
<td>ITRI (Taiwan)</td>
<td>0.1 mm</td>
<td>Blue (405 nm)</td>
<td>AVC</td>
<td>17G / na</td>
<td>31.59 Mbps</td>
</tr>
</tbody>
</table>
How long will it last?

- Depends on how you store them!
- **MARKING WITH BALL POINT PEN WILL ALMOST CERTAINLY DESTROY THEM.**
- Light (UV and Sunlight) cause dye to fade on ‘R’ disks.
- Humidity can cause corrosion on the metal layer.
- Temperature extremes can damage the plastic or cause separation.
- Organic solvents can dissolve the polycarbonate!
- Microwave ovens can destroy disks (metal layer)
- Fingerprints, surface scratches, dirt, dust, solvents, moisture can all interfere with the ability of the laser to read the data.
- Wear from disk play?
  - ROM disks – no effect.
  - -R disks, may have only several thousand read cycles due to cumulative effects of laser.
  - RW disks write cycles in the 1000s, but successive writes may impair number of read cycles allowed. Media can ‘wear out’.
How LONG DO MANUFACTURERS SAY IT WILL LAST?

• Among the manufactures who have done testing:
  – CD-R, DVD-R, DVD+R should have a life expectancy of 100 to 200 years or more given ideal conditions. Organic dye deterioration is the expected failure mode. Most CD-R and DVD-R disks have a shelf life of 5y – 10y before recording, but no expiration dates are currently printed on these packages.
  – CD-RW, DVD-RW, DVD+RW, and DVD-RAM should have a life expectancy of 25 years or more. Phase change film is primarily effected by heat, but UV light may also contribute to the aging process.
  – Little information is available about CD-ROM and DVD-ROM, but expectations are from 20 Years to 100 years. (oxygen and humidity can degrade aluminum substrate) Cool and dry environment is best. High humidity and elevated temperatures can accelerate the oxidation rate.
  – Tests of accelerated aging at NIST show one type of DVD-R for authoring to be 30 years if stored at 25C and 50% relative humidity.
Where to get more info?

• Software sites:
  – Easy CD-Creator (formerly Adaptec) now Roxio
    • www.roxio.com
  - Ahead Nero
    - www.nero.com
  - FAQs Both over 100 pages long…
    - http://dvddemystified.com/dvdfaq.html
    - http://www.cdrfaq.org/
  - Other web info
    - http://electronics.howstuffworks.com/dvd.htm