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# DVD-RAM...

## The Rewritable, High-Capacity Technology for Today and Tomorrow

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Presented at THIC meeting at the Hotel Villa , San Mateo CA on July 22, 1998.



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# Rewritable DVD Brings:

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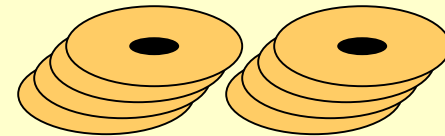
## Protection of data investments

Reads all CD and DVD Formats



## High capacity storage

5.2 GB (Capacity of 8 CD-RW discs)



## Lowest cost rewritable, random access media

Cost of media is less than one cent per MB



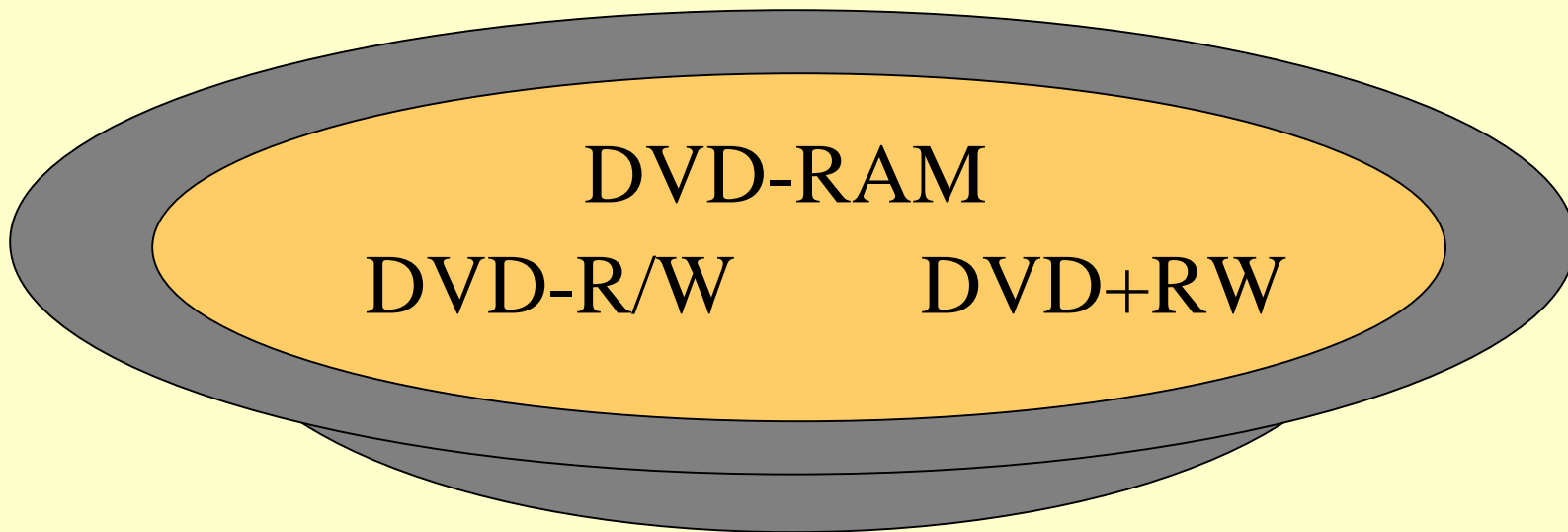
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# Rewritable DVD Also Brings:

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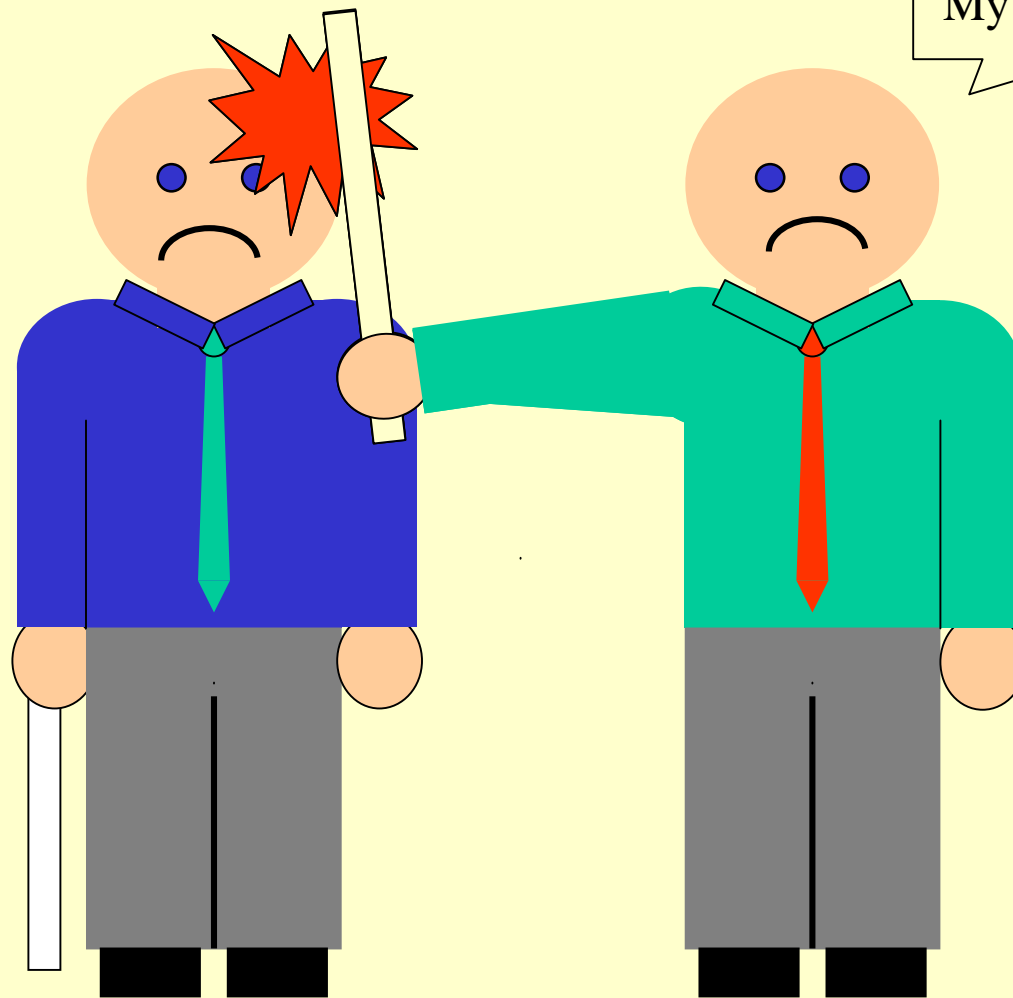
## Confusion

With an alphabet soup of formats



# Two Engineers Fighting

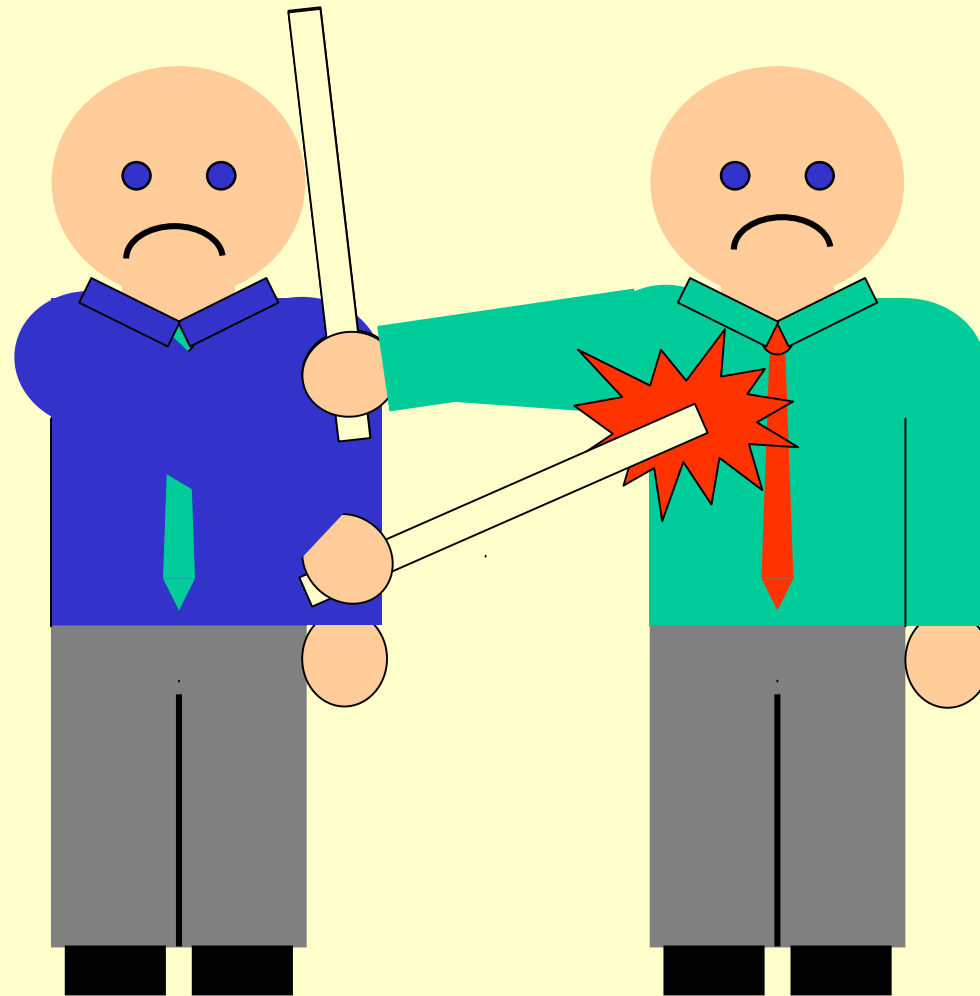
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# Two Engineers Fighting

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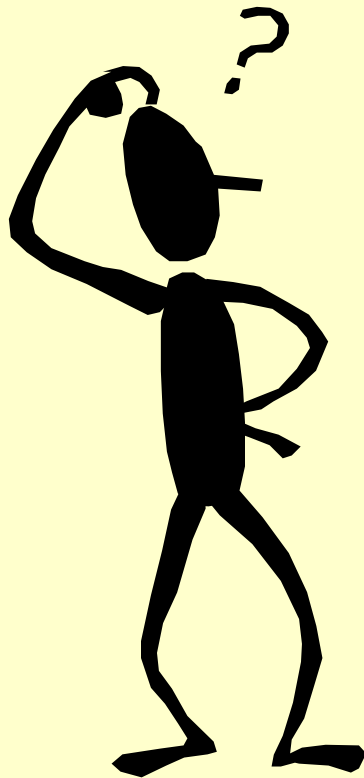
My Design is Best



# Let the Market Decide

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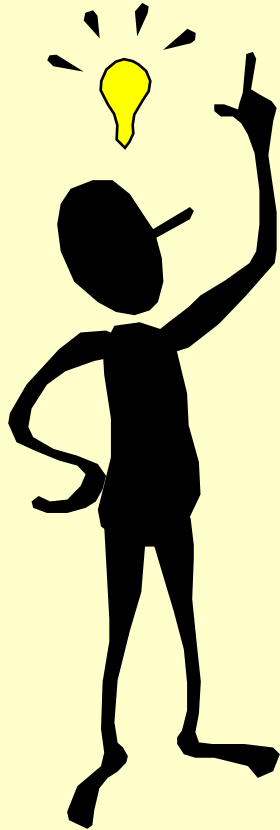
**There are distinct differences between the rewritable DVD formats.**



# Let the Market Decide

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There are distinct differences between the rewritable DVD formats.



And when one understands these differences, **DVD-RAM** is clearly superior.



# Contents of Presentation

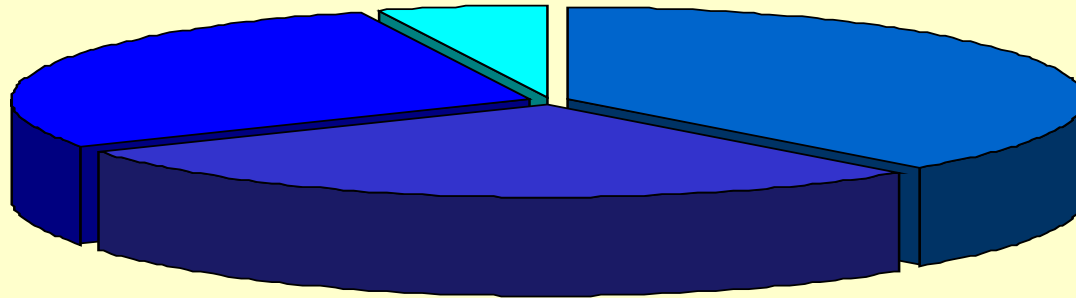
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- **Current Status of DVD-RAM Drives**
- **Advantages of the DVD-RAM Format**
- **Opportunities Provided by DVD-RAM**
- **Future Developments in the DVD-RAM Format**



# DVD-ROM Manufacturers Support

## Percentage of DVD-ROM Drive Market Share



Source: DataQuest

■ ■ ■ DVD-ROM Manufacturers Supporting DVD-RAM

(Over 94% of DVD-ROM drive market share belongs to drive manufactures who support the DVD-RAM format)



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# DVD-RAM Is Available Today

**Panasonic** LF-D101U  
DVD-RAM DRIVE

- Up to 5.2 GB rewritable storage
- Less than one cent per MB media cost
- Over 30 years media shelf life
- Fast data access and data transfer
- Reads all popular CD formats

**DVD RAM**

## Panasonic LF-D101U DVD-RAM Drive



DVD-RAM Drive	
Interface	IDE (ATA-6)
ATA Connector Type	34-pin ribbon connector
Media Support	Read/Write: DVD-RAM, DVD-R*, CD-R/M, M-Code, ED-RW*, CD-DA, Video CD, ED-UTM, PhotoCD Multisession
Seek Time	DVD-RAM: 1.0K ms DVD-ROM: 20 ms CD-ROM: 20 ms
Rotational Data	DVD-RAM: 1,200 RPMs
Transfer Rate	DVD-RAM: 2,273 KB/sec (2x) CD: 1.8 - 1,101 KB/sec CD-ROM: Up to 3,000 KB/sec (24x)
Buffer Memory	2 MB
Audio Output Level	Headphone Jack: 0.31 Vrms (20K) Line Out: 0.81 Vrms (10K)
Drive Orientation	Horizontal or vertical
MTBF	25,000 Hours
Power Requirements	DC +5V - 0.1V @ 1.5A DC +12V - 0.5A (Max.)
Operating Temperature	+11° - 131° F (5° - 41° C)
Operating Humidity	5% - 85% RH
Dimensions	3.94" x 11.96" x 1.56"
Weight	2.2 lbs. / 1 kg.
Warranty	Limited one year parts & labor www.panasonic.com 1-800-FRAME-1111 (800-328-2711)
Technical Support	

### A NEW ERA FOR REWRITABLE OPTICAL STORAGE.

Panasonic's LF-D101U DVD-RAM drive usher's in a new era for rewritable optical storage. Many innovations have been incorporated to produce an extremely reliable, high performance storage solution. All of these innovations combine to give a single-sided recording capacity of 2.6 GB and a double-sided capacity of 5.2 GB. Additionally, the built-in error correction, embedded address bits, vectored track recording and other features make DVD-RAM a highly reliable media.

DVD-RAM is the choice for rewritable, removable data storage providing many benefits such as:

- Less than 1 cent per MB media cost
- Over 30 years media shelf life
- 8 times the capacity of CD-RCD RW
- Fast data access and data transfer
- Reads DVD and CD discs

The LF-D101U comes with all the necessary mounting parts, as well as easy-to-install and use software for Windows 95.

- Windows 95 device driver
- LDF (Logical File System)
- MFTS (Real-time embedded software)
- Backup software
- Utility software

One 2.6 GB single-sided DVD-RAM disc (JM-D0262) is also included.

Panasonic Electronic Systems Sales Company  
A Division of Panasonic Communications & Service Center  
Atsugi-City, Kanagawa-Prefecture, Japan  
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MS-1000-001000

**Panasonic**

Technical Support: 1-800-328-2711  
1-800-FRAME-1111

For More Information on Panasonic DVD-RAM, Visit our Website at [www.panasonic.com/storage](http://www.panasonic.com/storage)

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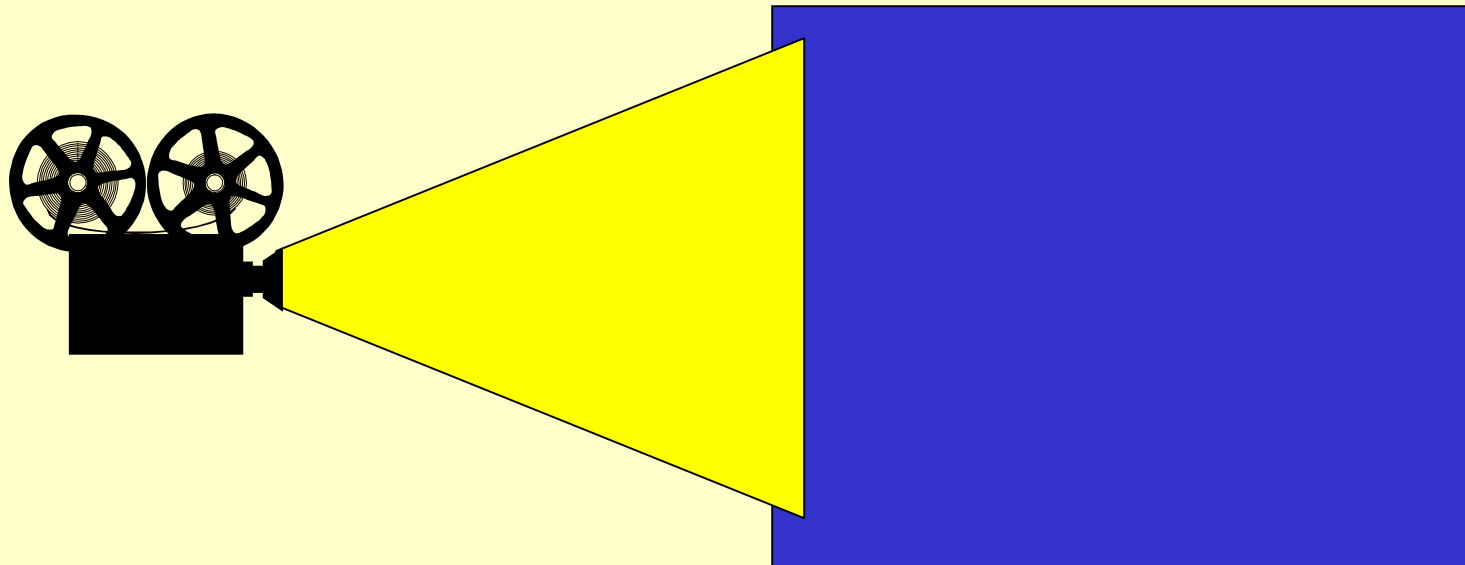
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# DVD-RAM Is Being Used Today

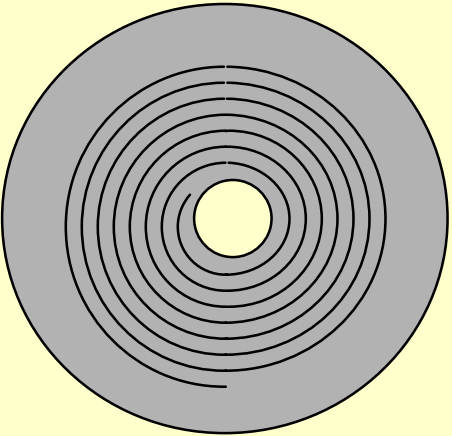
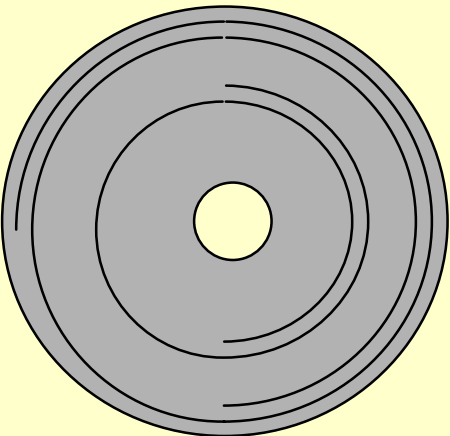
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This presentation is stored on DVD-RAM media

This PC is accessing the presentation from a DVD-RAM drive



# Rewritable Formats

	<u>Record Once</u>		<u>Rewritable</u>	
1997	DVD-R 3.9 GB		DVD-RAM 2.6 GB	+RW 3.0 GB
1998	DVD-R 4.7 GB	DVD-R/W 4.7 GB	DVD-RAM 4.7 GB	
Physical layout of data		Format for creation of DVD-ROM test discs. Limited number of rewrites		Format for data storage, distribution and backup.

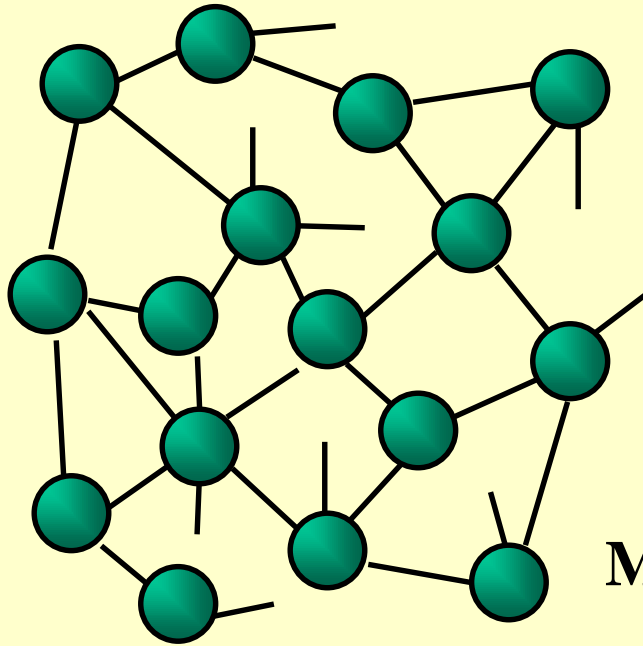
Available Products
  Specification Released by DVD Forum
  Under development by DVD Forum



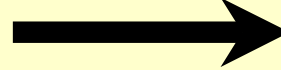
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# Phase Change Technology

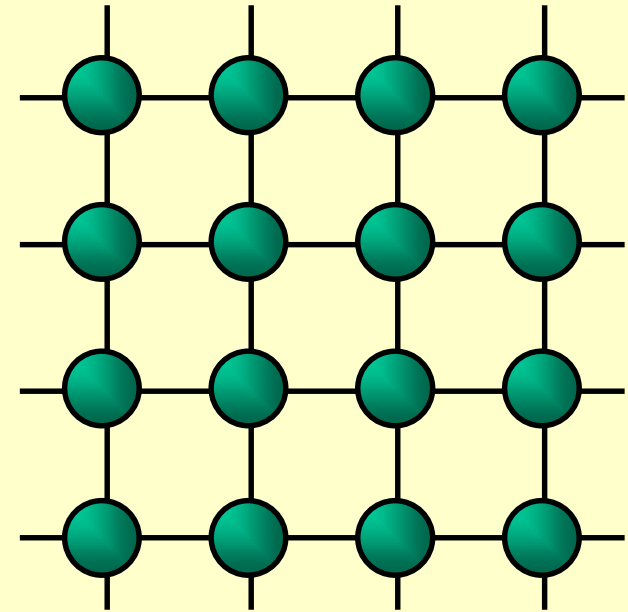
Amorphous



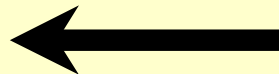
Anneal



Crystalline



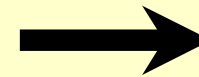
Melt & Quench



Small



Reflectivity



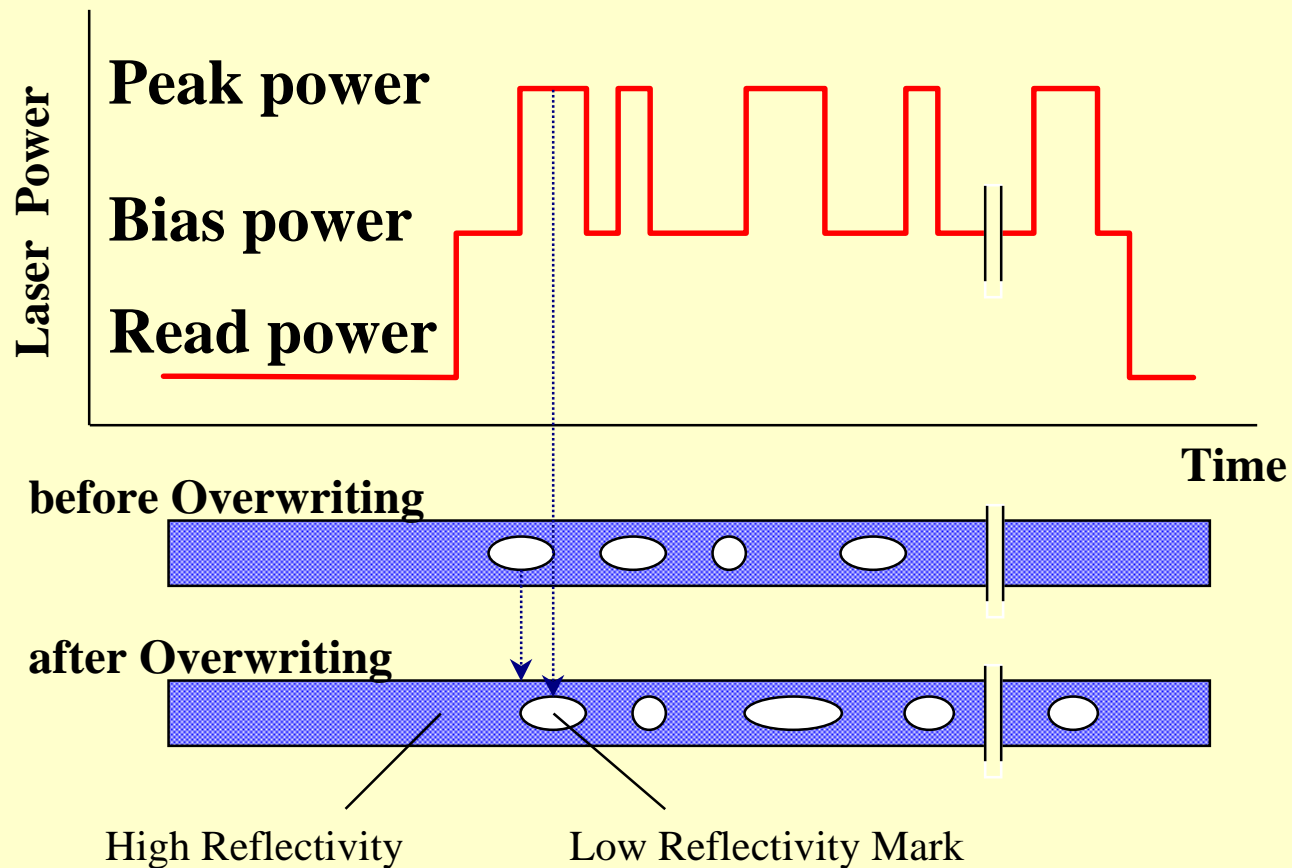
Large



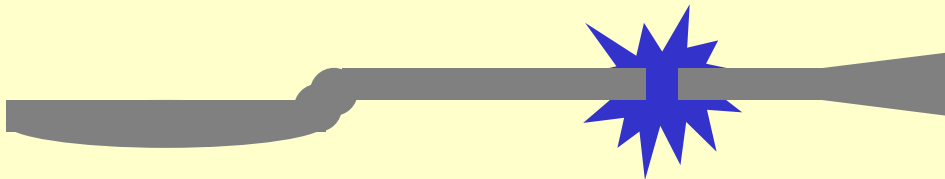
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# Phase Change Rewrite Process

A laser is used to create low reflective marks.

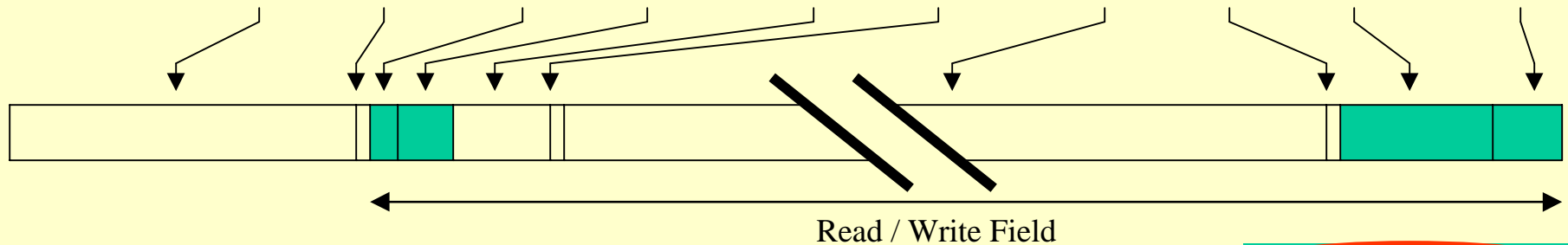


# Bit Shifting



## DVD-RAM Physical Sector

Segment Name	Header Field	Mirror Field	Gap Field	Guard 1 Field	VFO 3 Field	PS Code Field	Data Field	PA 3 Field	Guard 2 Field	Buffer Field
Byte Count	128	2	$10+J/16$	$20+K$	35	3	2418	1	$55-K$	$25-J/16$



J: 0 to 15    K: 0 to 7

### Rewrites

**DVD-R/W: 1000**

**DVD-RAM: greater than 100,000**



# Rewritable DVD Differences

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**Capacity:** 2.6 GB verses 3.0 GB

Increase in capacity reduces: Performance  
Data Reliability

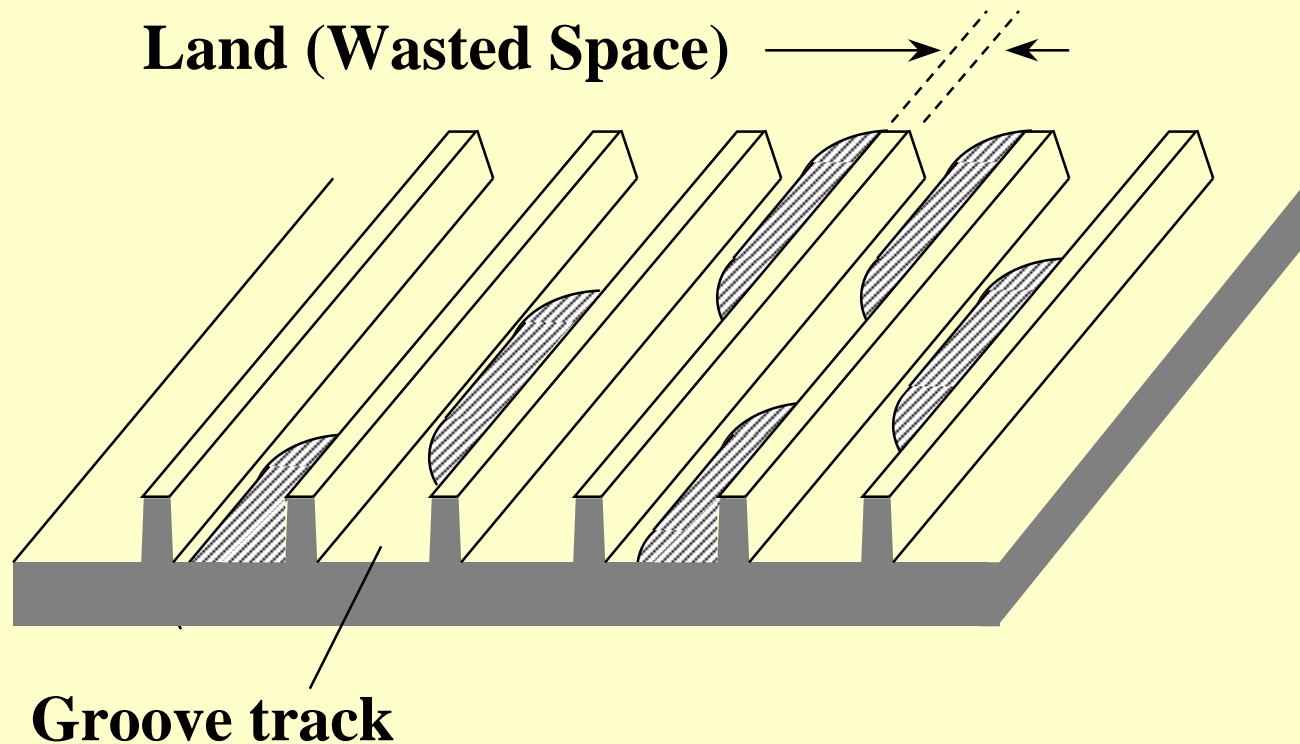
**Cartridge:** Cartridge verses No Cartridge

Lack of cartridge reduces: Data Protection



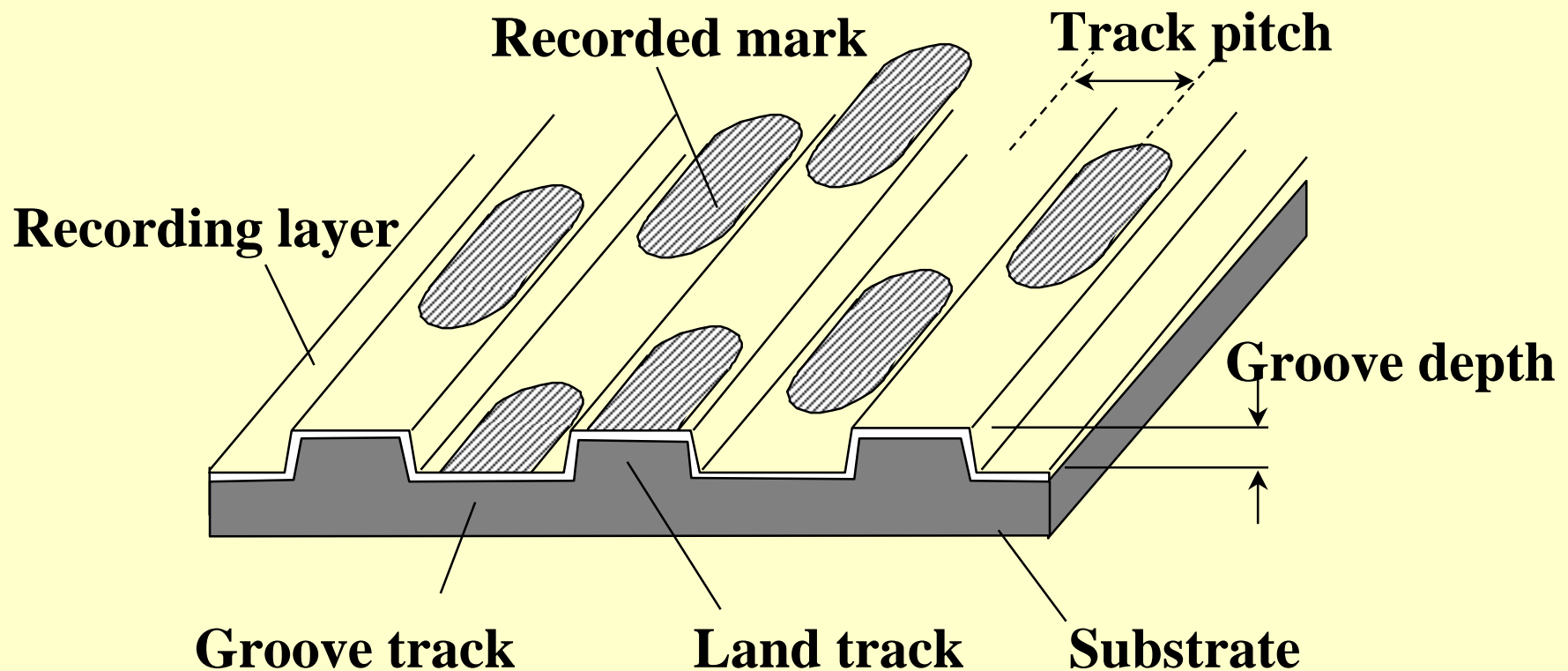
# Groove Only Recording

With the +RW format, marks are also placed along a continuous spiral track. The spiral track is defined by a continuous groove. Marks are only placed in the groove. This is inefficient. The land area is not used to store information.



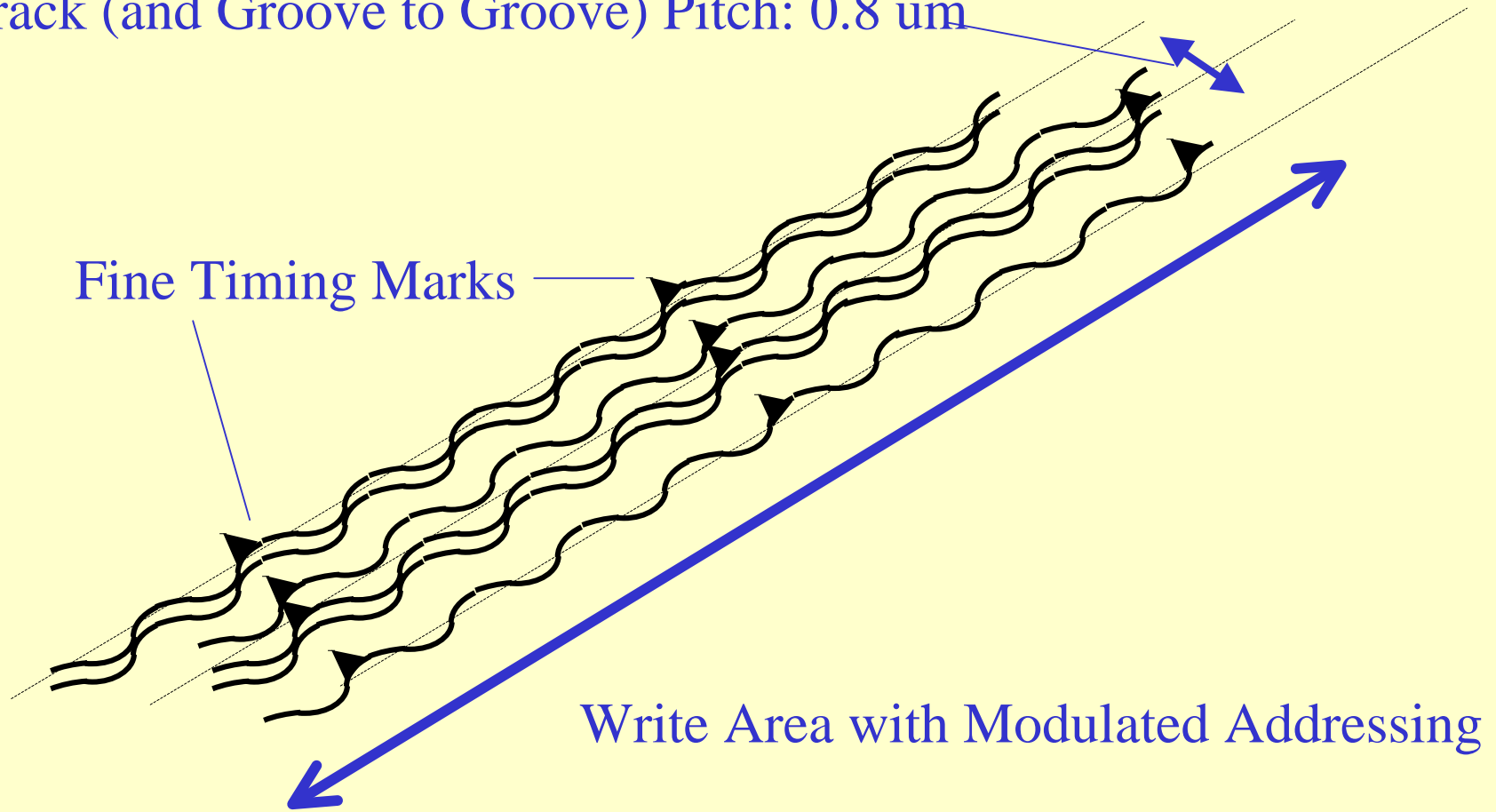
# Land and Groove Recording

With the DVD-RAM format, marks are placed along a continuous spiral track. The spiral track is designed to allow marks to be placed both in the grooves and the space between the grooves (called lands).



# Wobble Modulation Addressing

Track (and Groove to Groove) Pitch: 0.8  $\mu\text{m}$



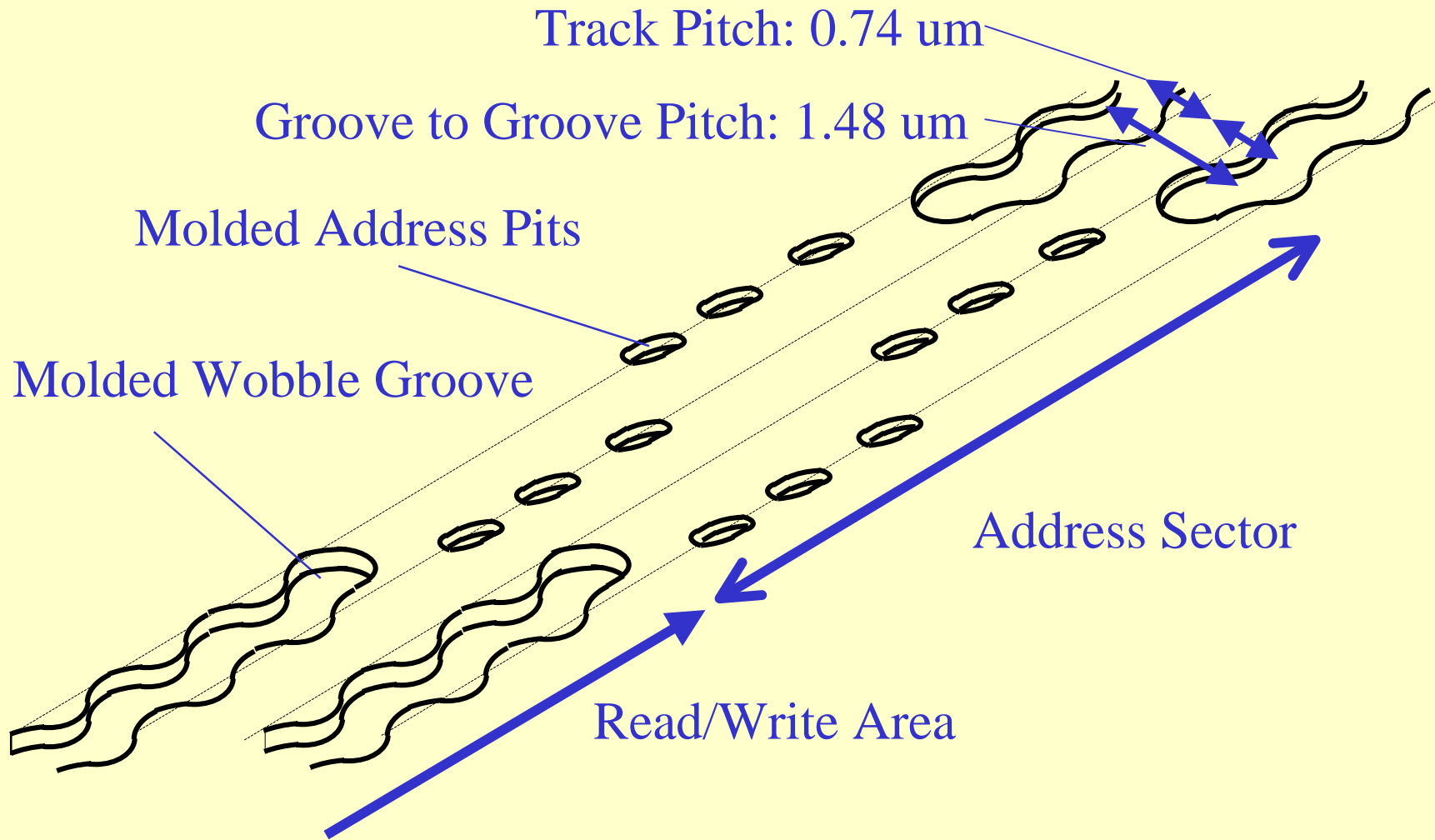
Fine Timing Marks

Write Area with Modulated Addressing



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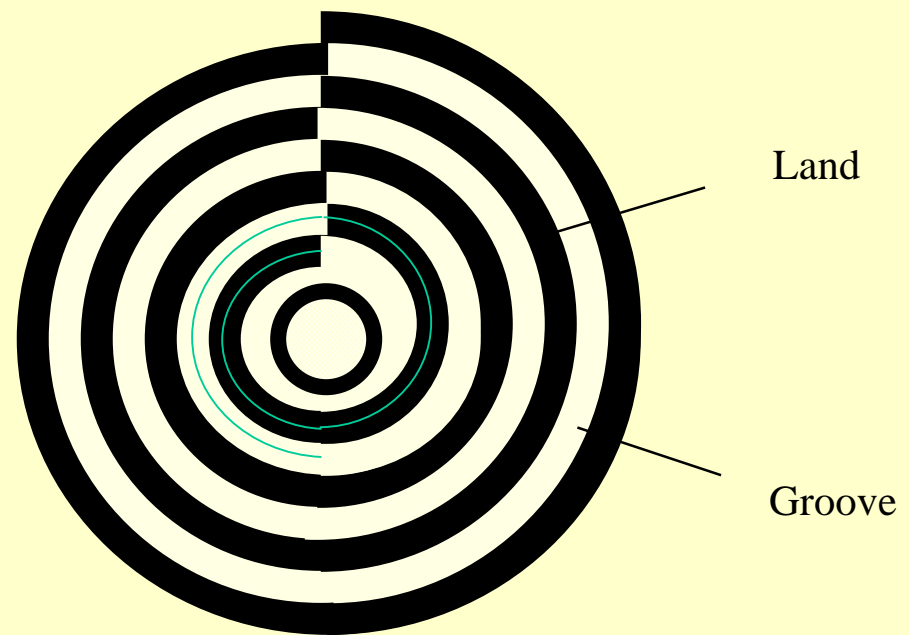
# Physical Addressing



# Tracking Transition

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With the DVD-RAM format, to allow marks to be laid out along a continuous spiral track, a transition between groove and land or land and groove occurs every rotation.

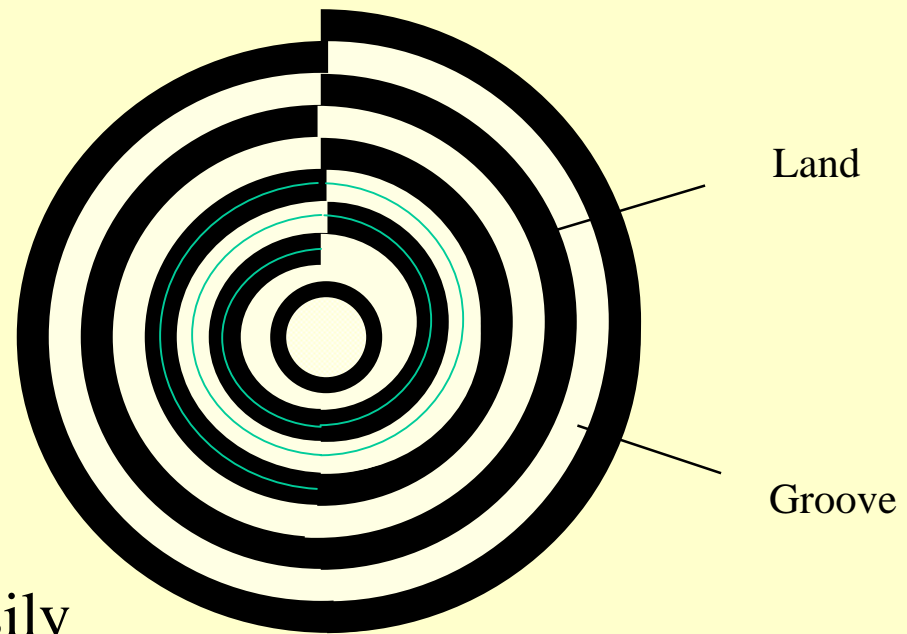


# Tracking Transition

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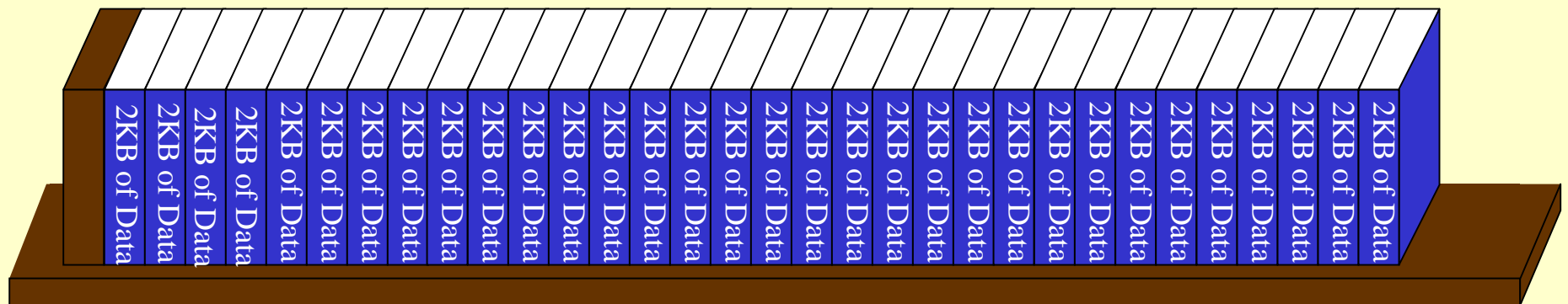
With the DVD-RAM format, to allow marks to be laid out along a continuous spiral track, a transition between groove and land or land and groove occurs every rotation.

DVD drives are designed to allow data to be read from the two surfaces which exist in dual layer DVD media. Therefore DVD-RAM drives can be easily designed to write on the two surfaces of the groove and land DVD-RAM media.



# Formats

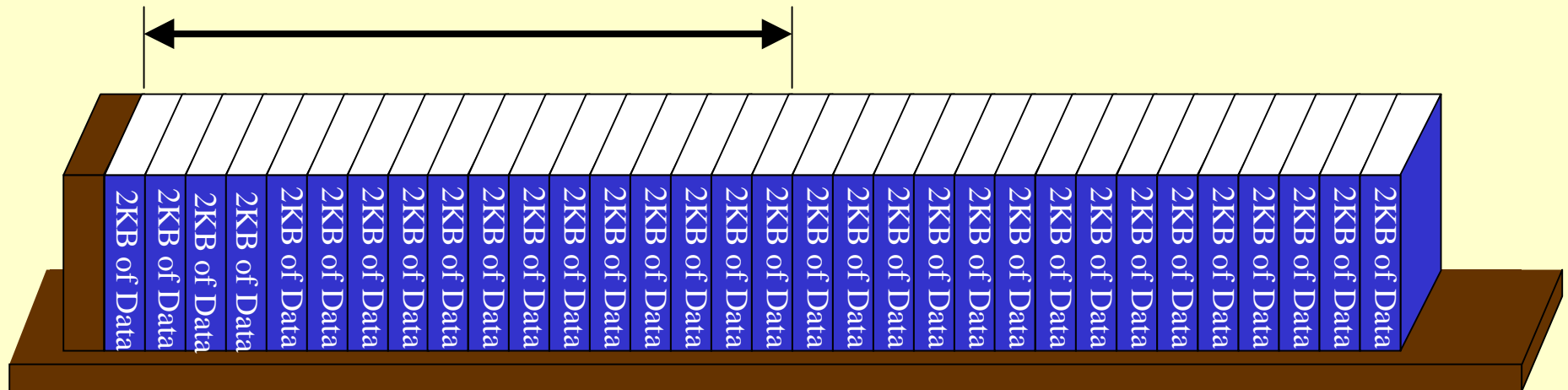
**DVD-ROM Format:** Pits are molded in to the media in a continuous spiral. The pits are grouped into physical sectors which contain 2KB of user data and timing info needed to read the data. A physical sector is the smallest group of data which can be accessed by a DVD-ROM drive. 16 sectors are grouped in an error correction code (ECC) block. Redundant data from each physical sector is distributed into other sectors in the ECC block. This allows read errors to be corrected.



# Formats

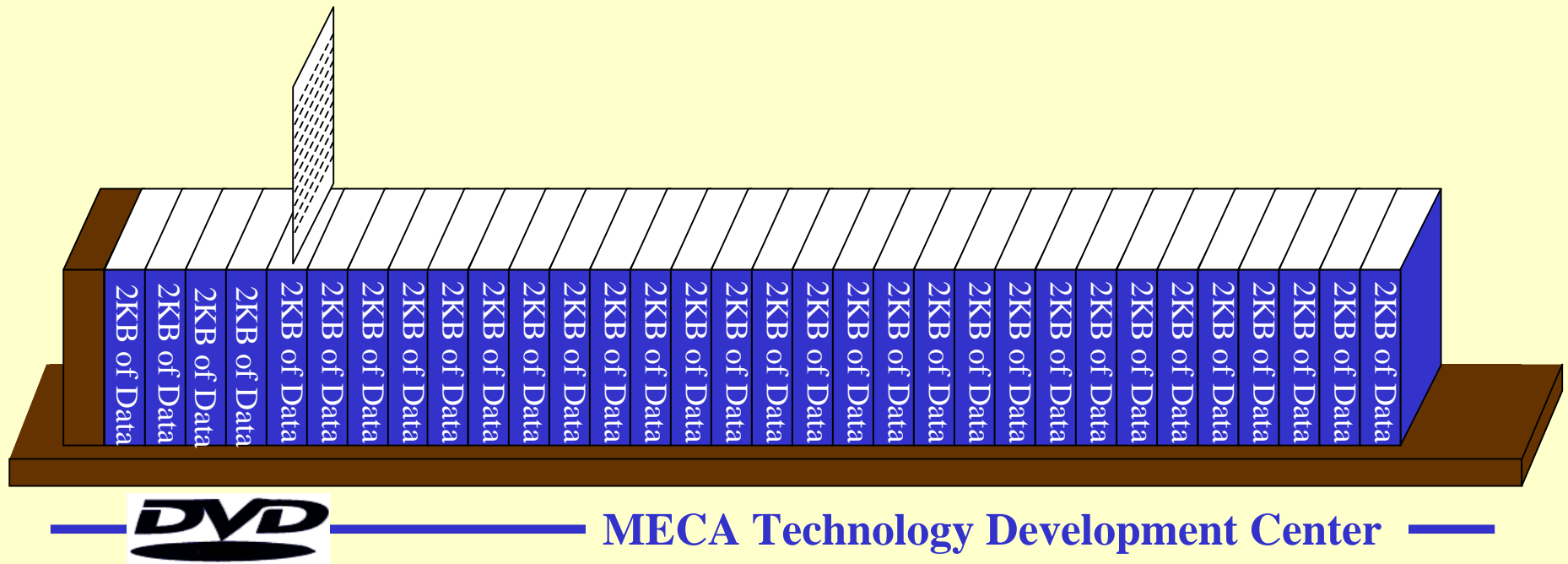
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16 Sectors form an ECC Block



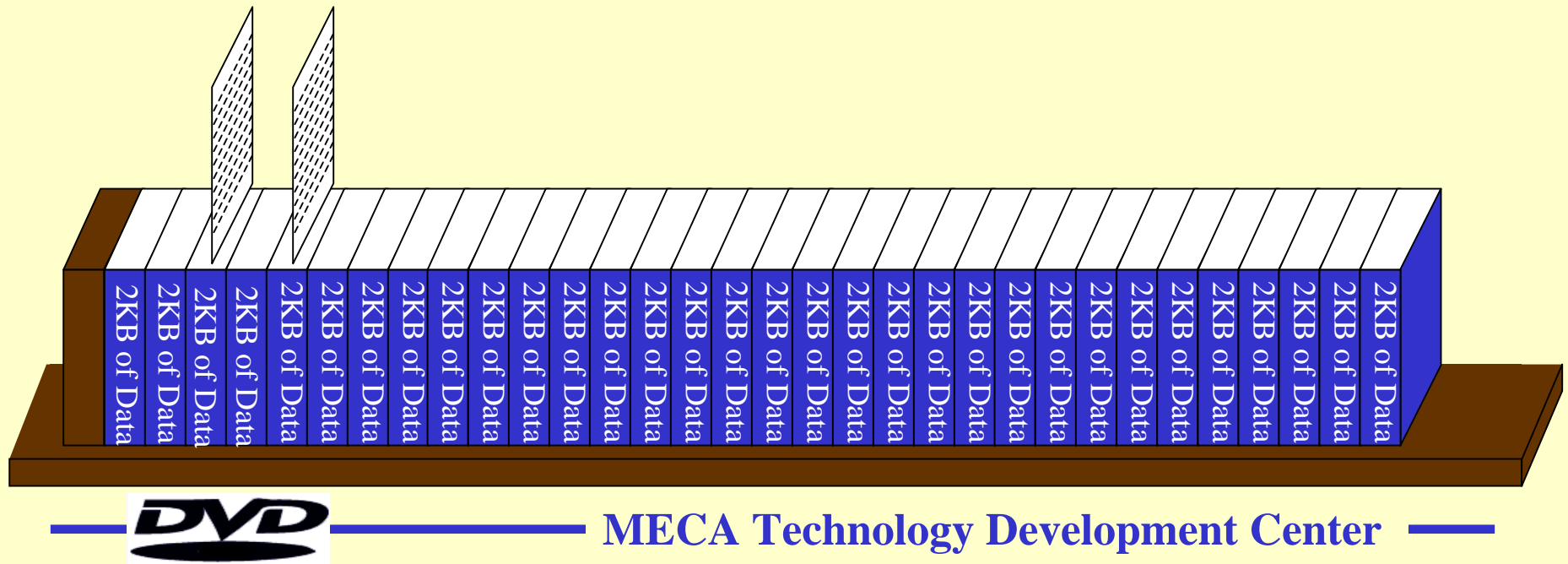
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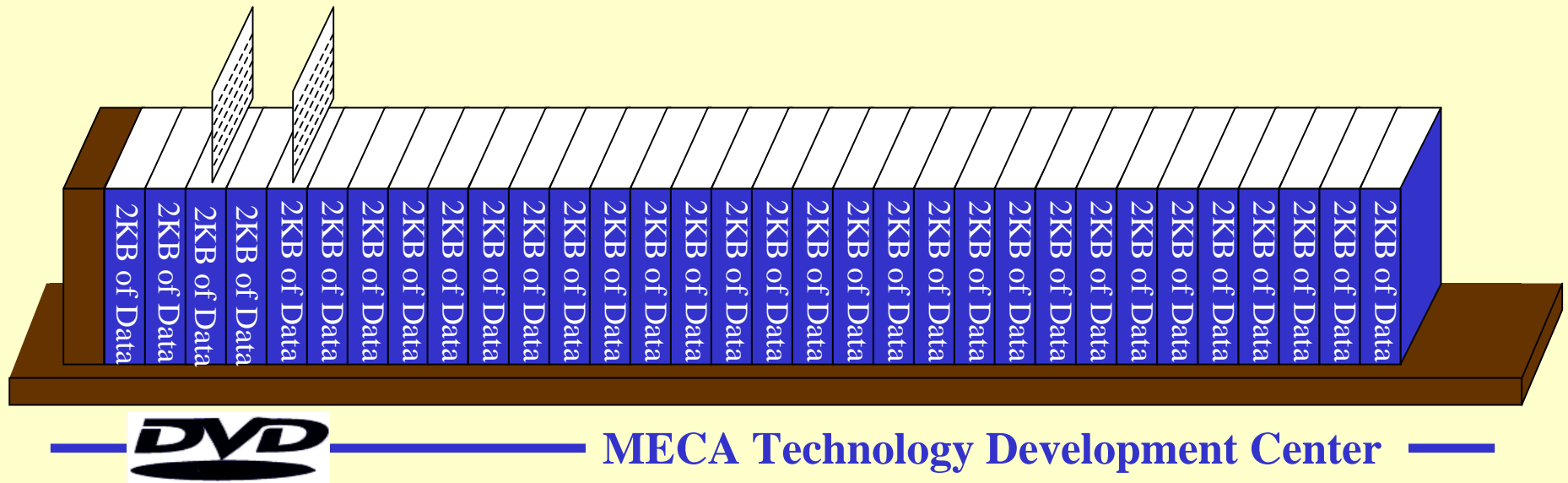
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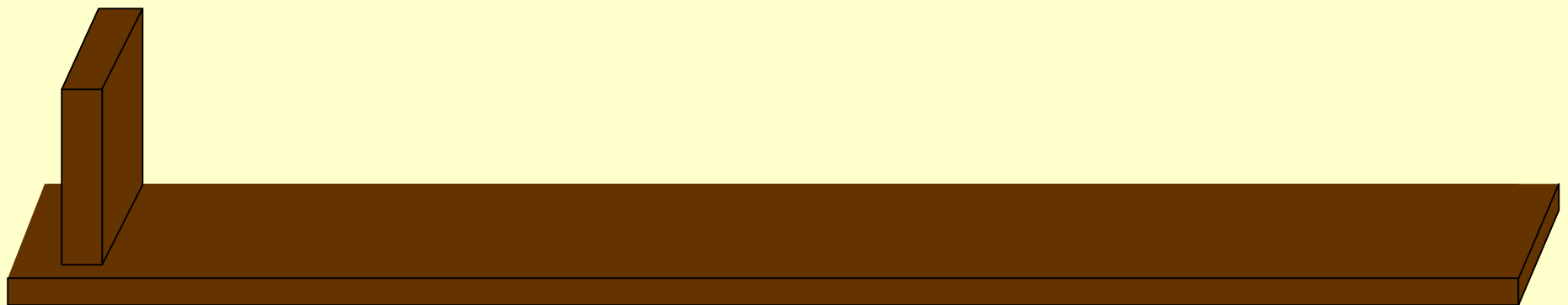


# Formats (continued)

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**DVD-RAM format:** Because this format allows data to be written to any location on the disk, distance along the spiral track must be indicated. Location information is molded into the spiral track. The spacing between the molded location addresses allows for the placement of a physical sector.

A good analogy is a book rack. The spiral track would be the bookshelf and the location addressing divides the shelf into numbered slots which can hold one book. A physical sector would be a book which can be placed at any location on the book rack.

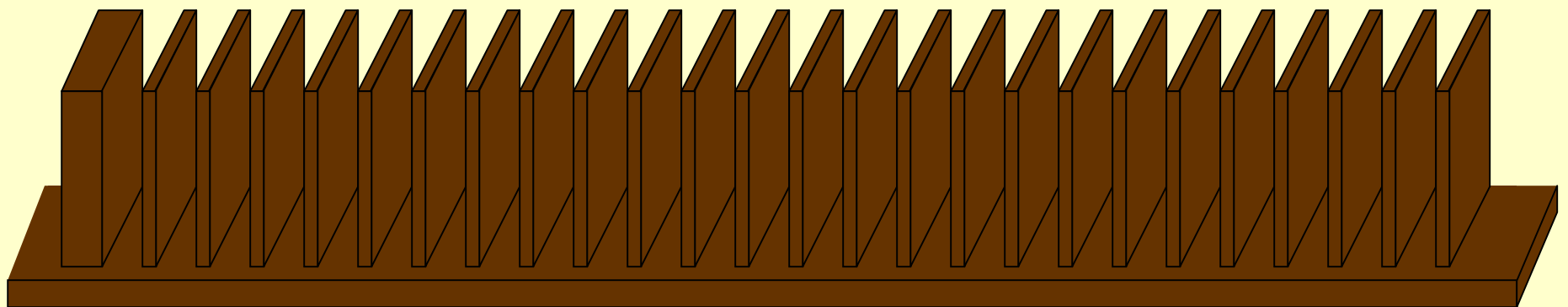


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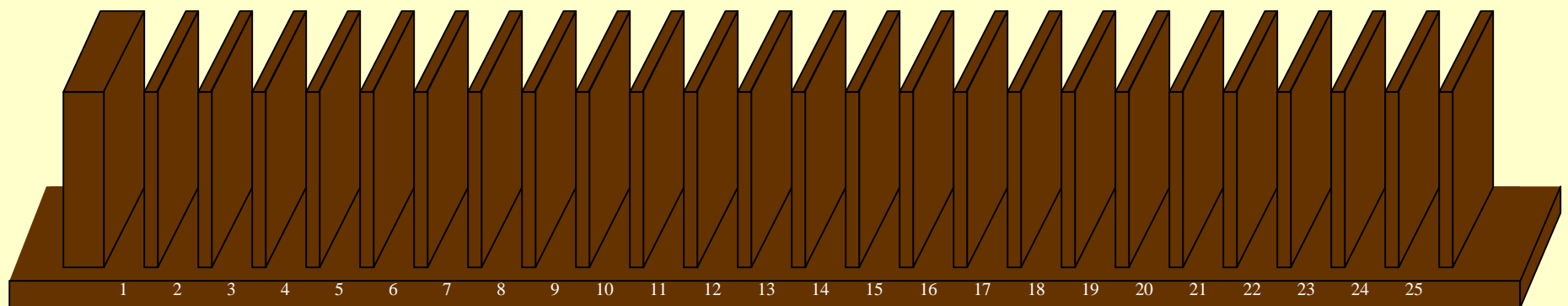


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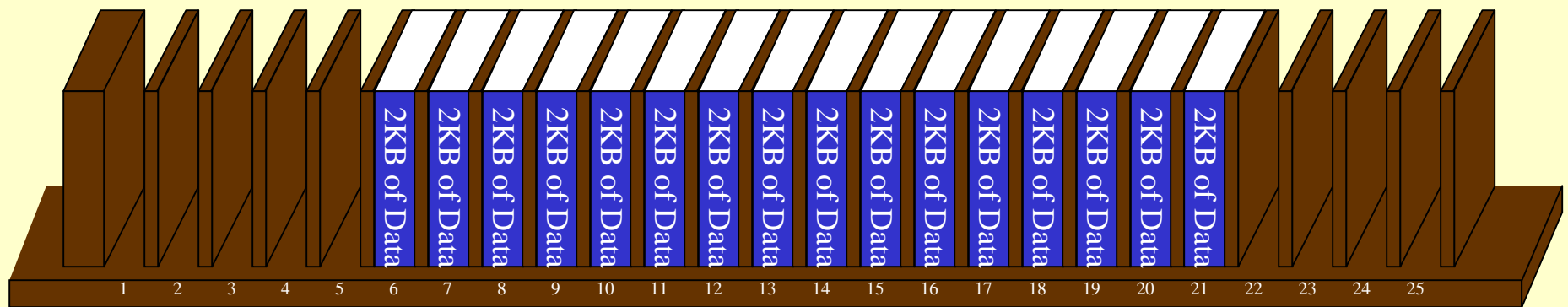
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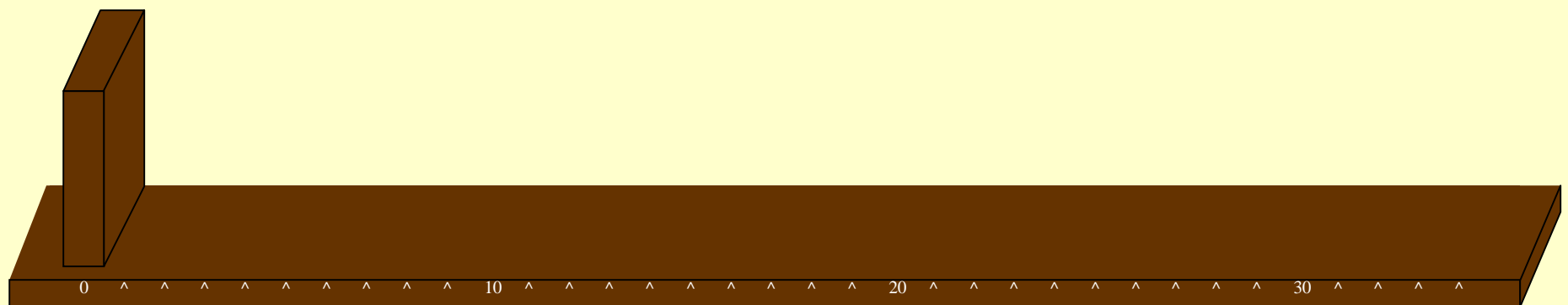
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**+RW format:** Limited addressing information is molded into the spiral track. Data is written along the track in groups of 16 physical sectors corresponding to an ECC block. To allow subsequent blocks to be written adjacent to the block, it is bracketed by two special sectors called linking sectors.

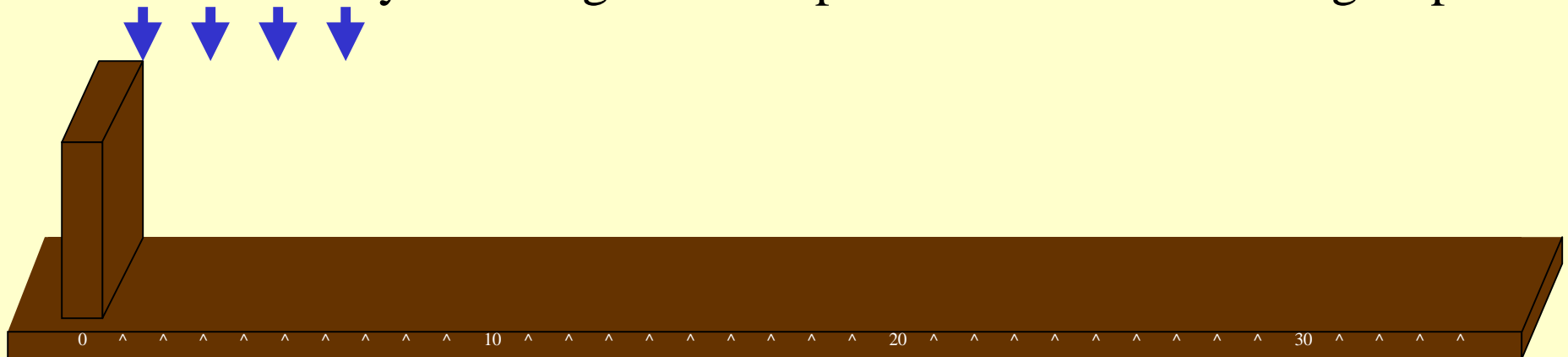
In the bookshelf analogy, position marks with limited addressing info are placed on the shelf. Once the correct position has been calculated a bookend which is the linking sector is placed on the shelf followed by 16 books. Finally a linking sector is placed at the end of the group.



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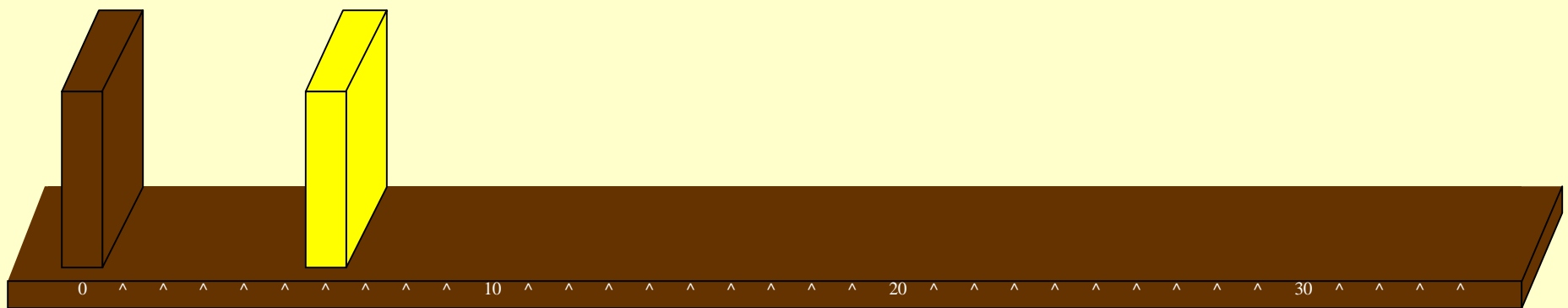
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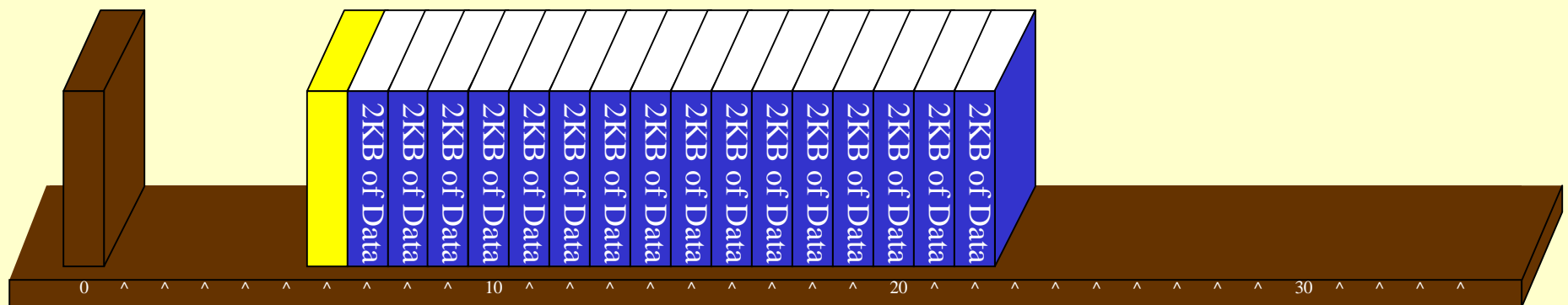
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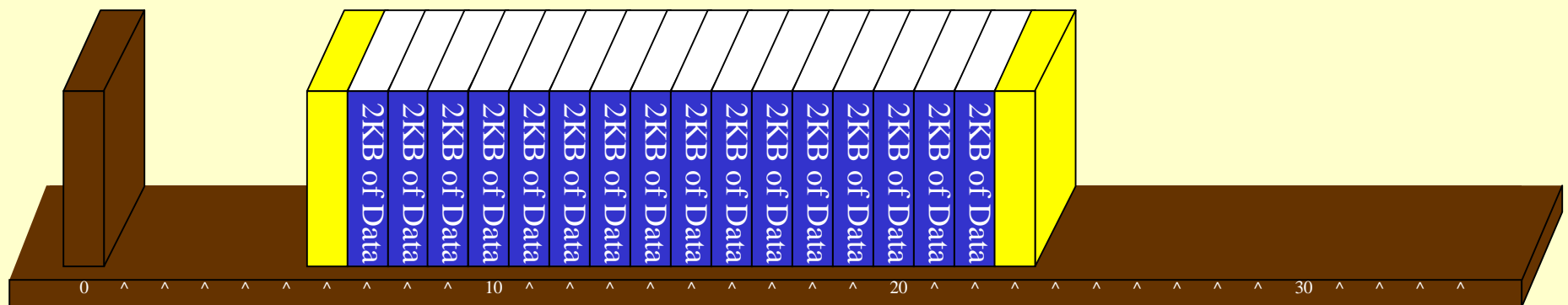
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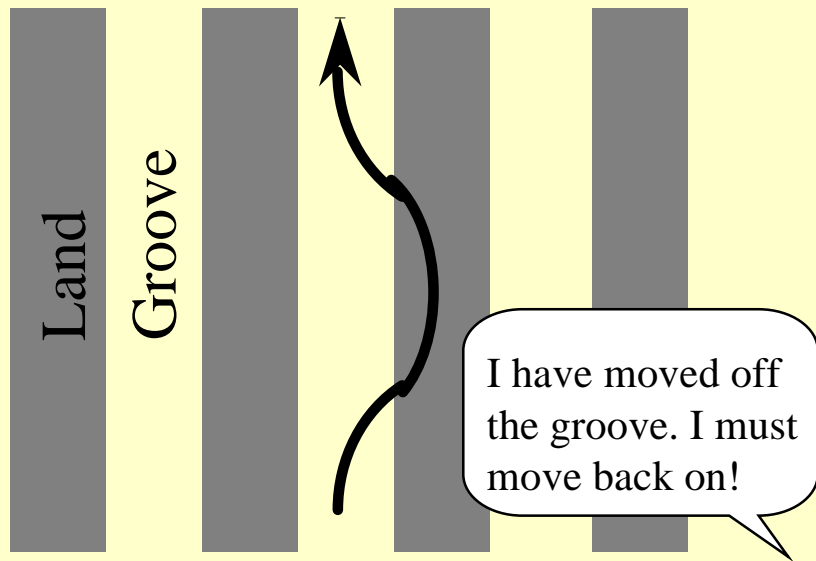
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# Tracking

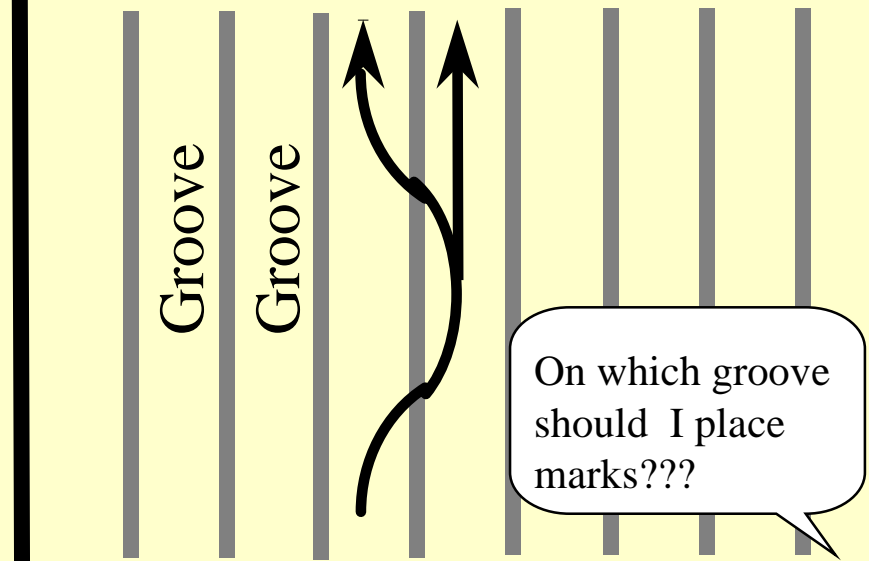
When only using grooves to write marks, the grooves must be packed closer together. It is more difficult to write a track of data in the correct location when only using grooves.

## Land and Groove



Easy to Place Track of Data

## Groove Only



Difficult to Place Track of Data



# Modulation Addressing

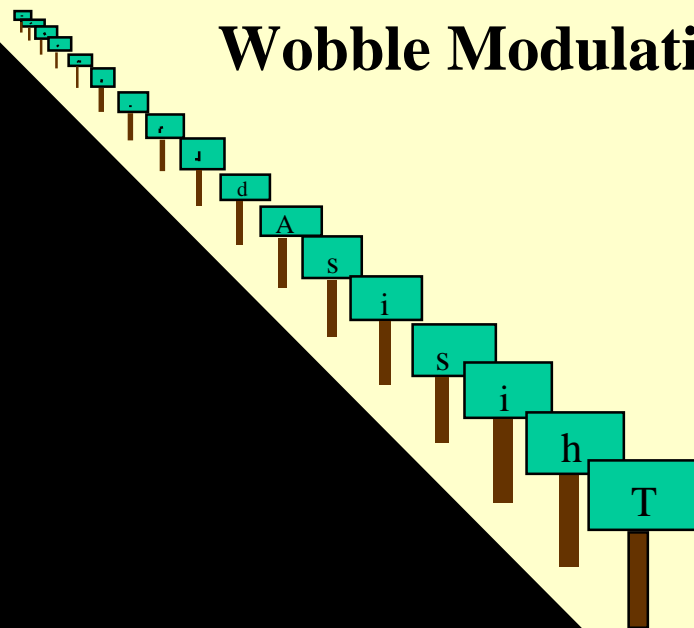
Address information can be modulated into the wobble groove, **BUT** positioning is not as accurate.

Physical Addressing

This is  
address 2325



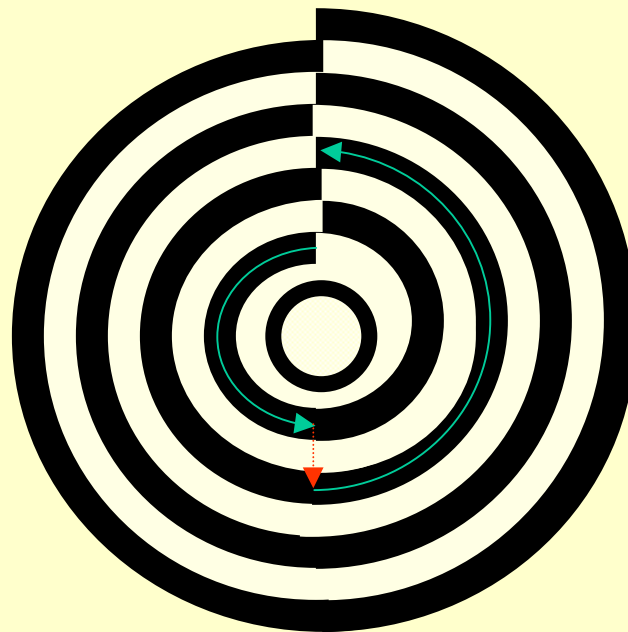
Wobble Modulation



# Tracking Errors

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If a drive is jarred or bumped during a write operation, it is possible for the write head to track at a new location and continue writing until the drive determines it is writing in the wrong location.

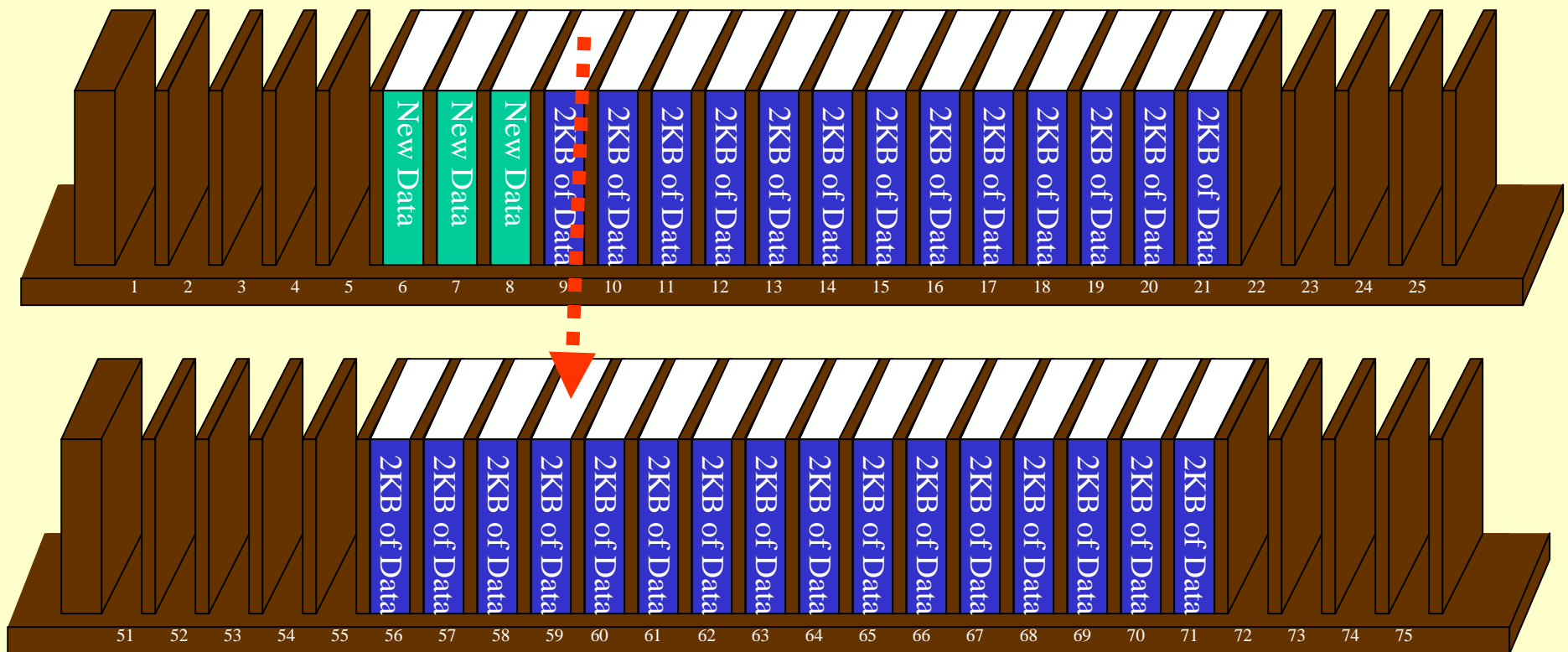


How does the DVD-RAM format handle this situation?



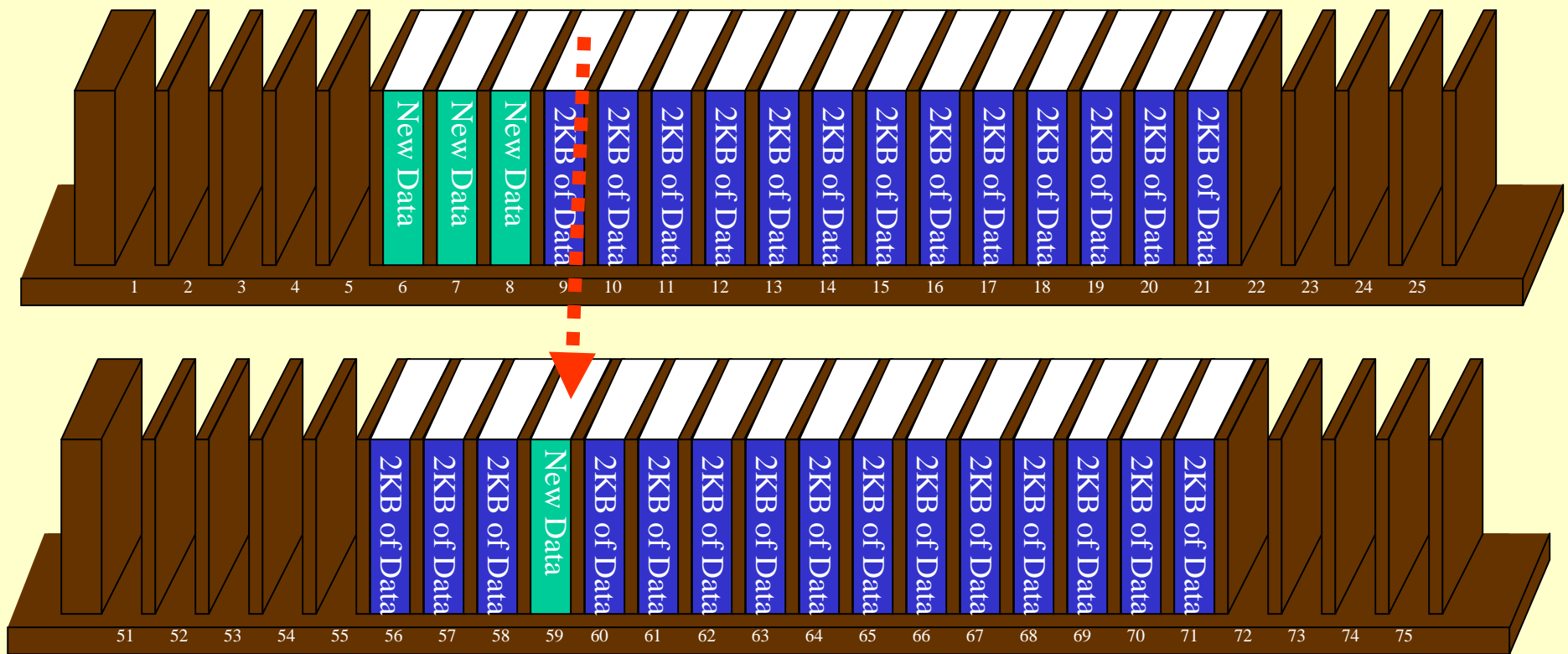
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Tracking Errors: highlight the advantage of the DVD-RAM format. DVD-RAM provides superior data integrity.



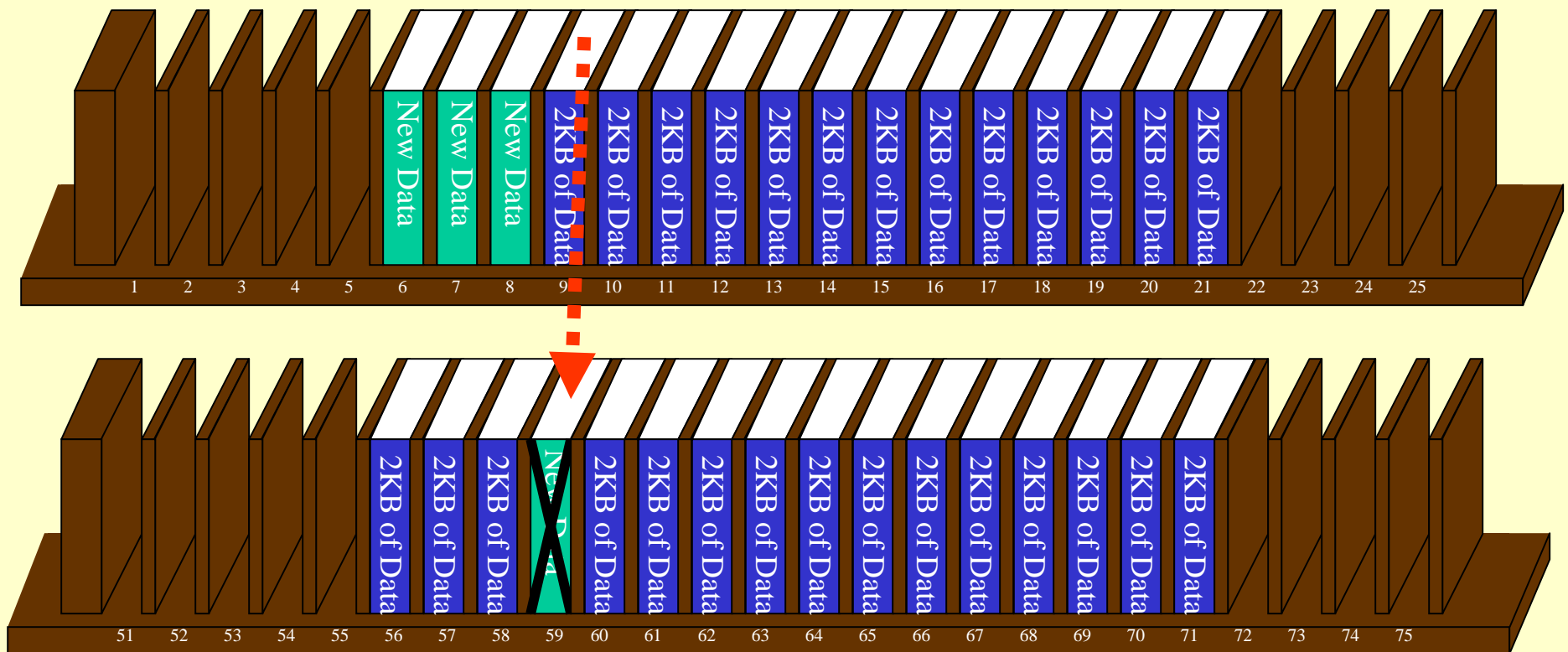
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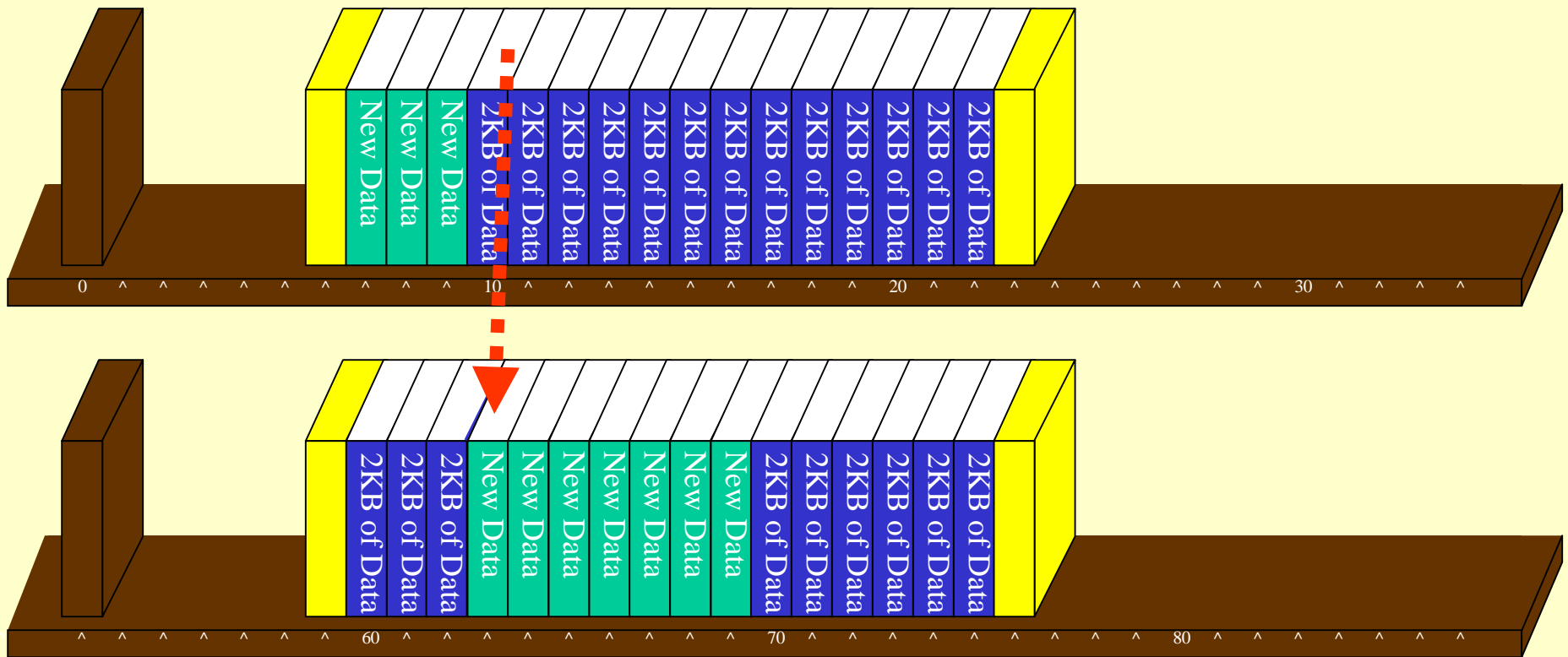
# Tracking Errors (continued)

Tracking Errors: highlight the advantage of the DVD-RAM format. DVD-RAM provides superior data integrity.



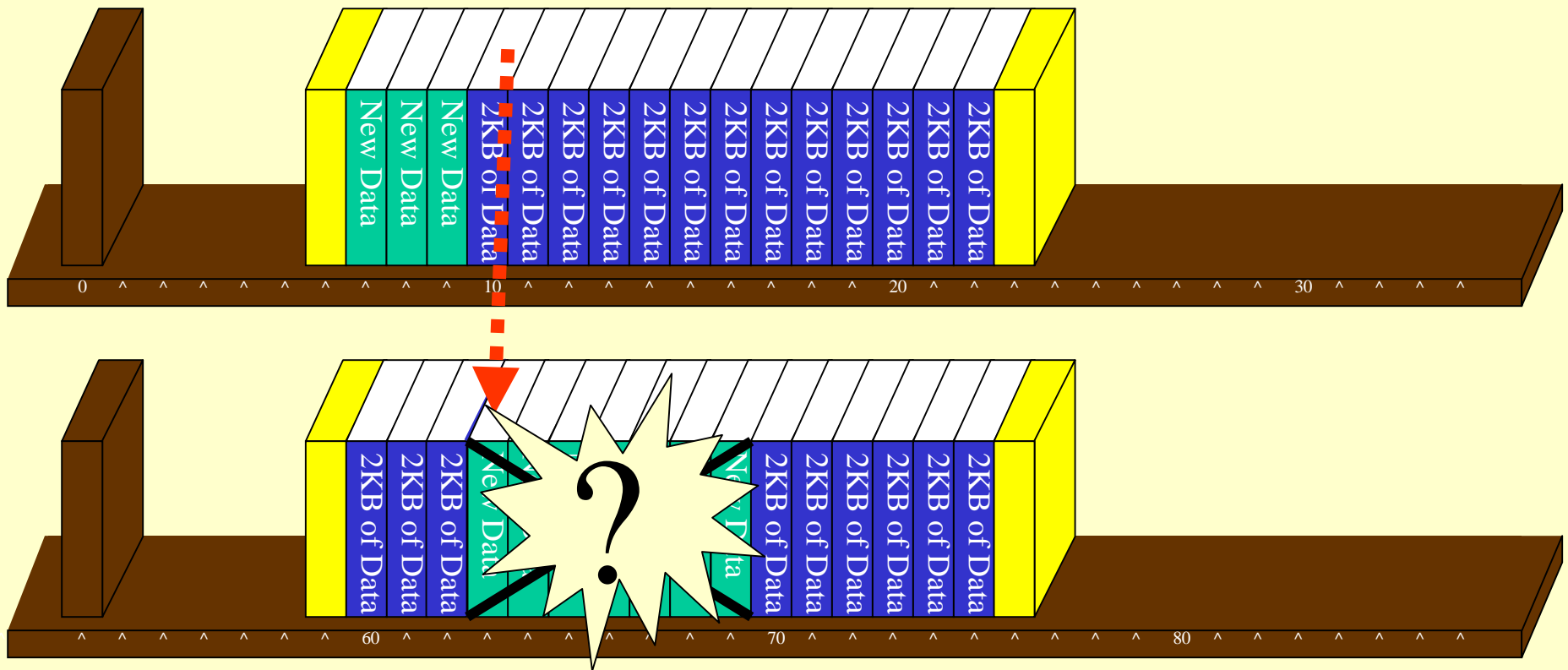
# Tracking Errors (continued)

Modulation addressing can result in large amounts of data being destroyed which will stress the error correction codes.



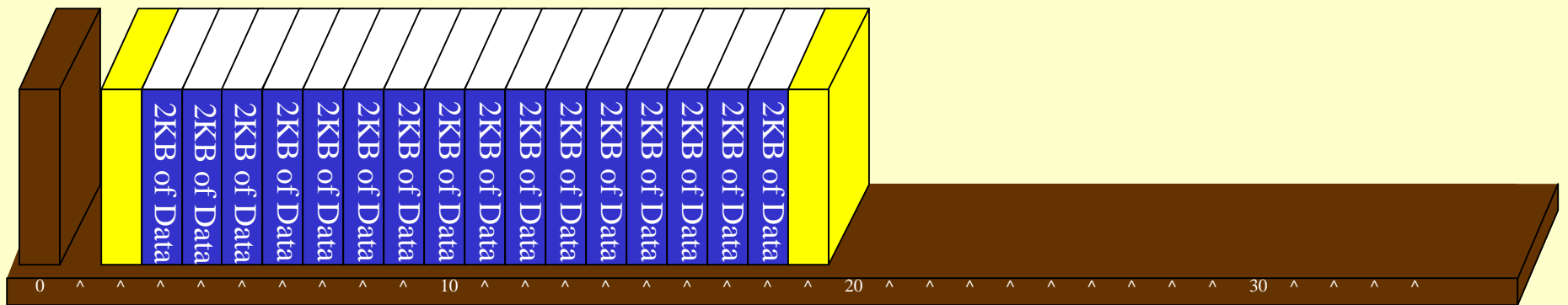
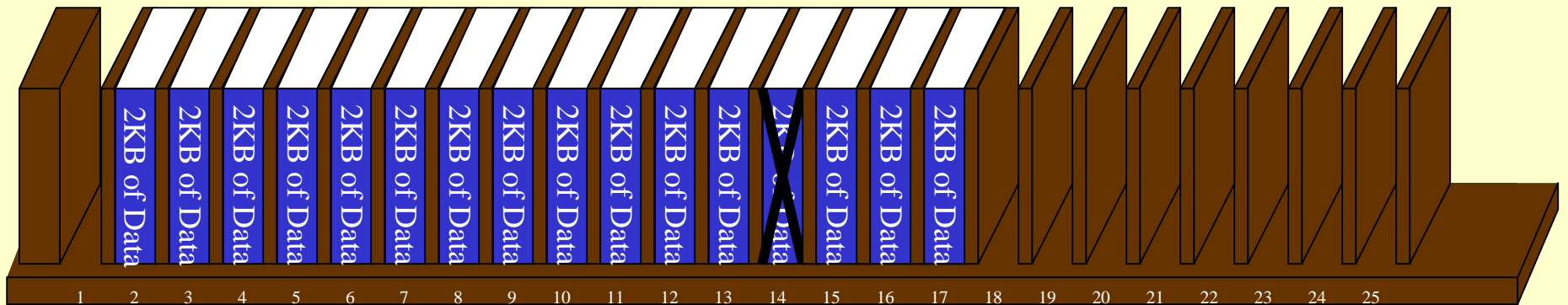
# Tracking Errors (continued)

Modulation addressing can result in large amounts of data being destroyed which will stress the error correction codes.



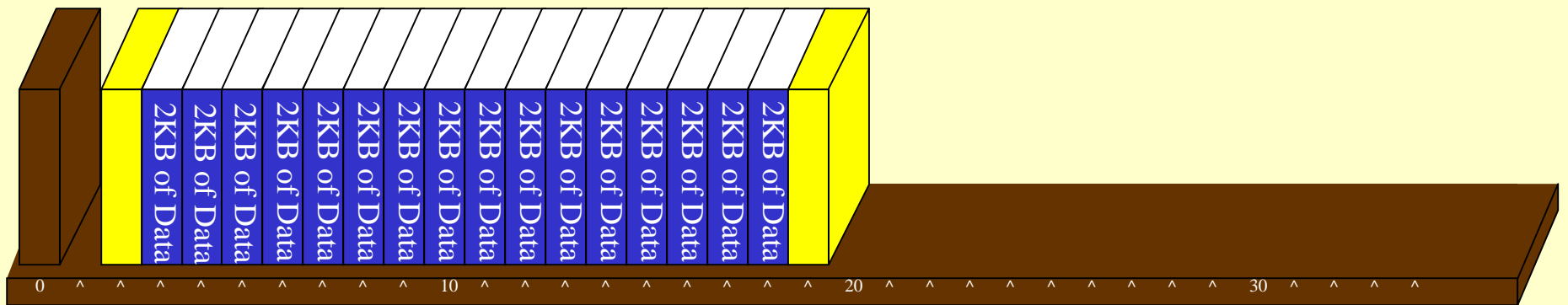
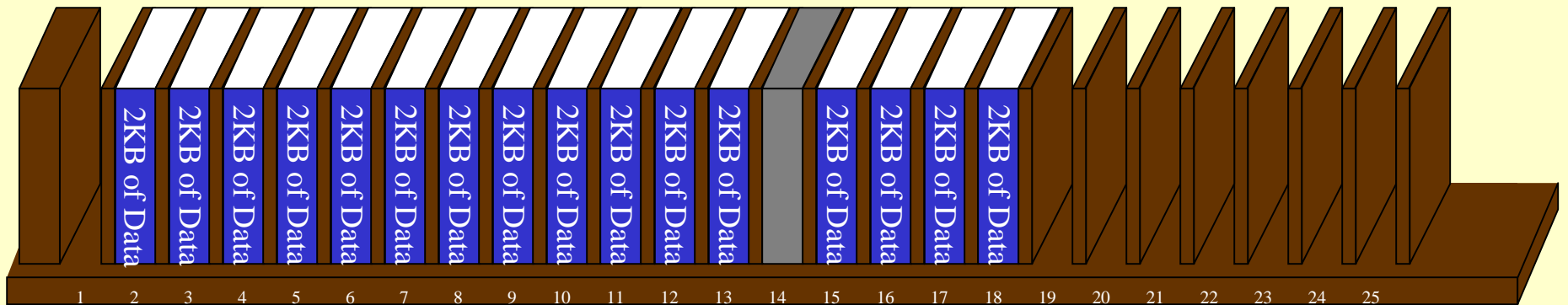
# Defect Management

Deflect Management: Also highlights the advantage of the DVD-RAM format. DVD-RAM allows data to be handled in much smaller packets making it 16 times as efficient.



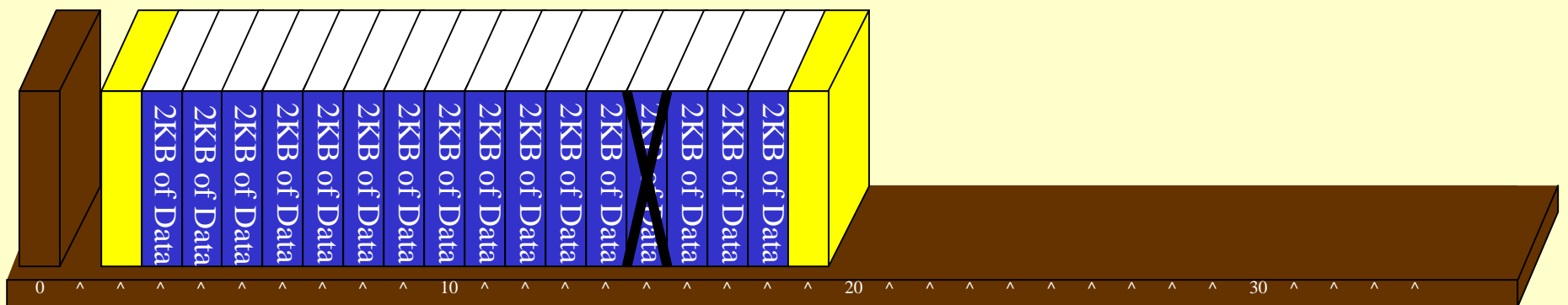
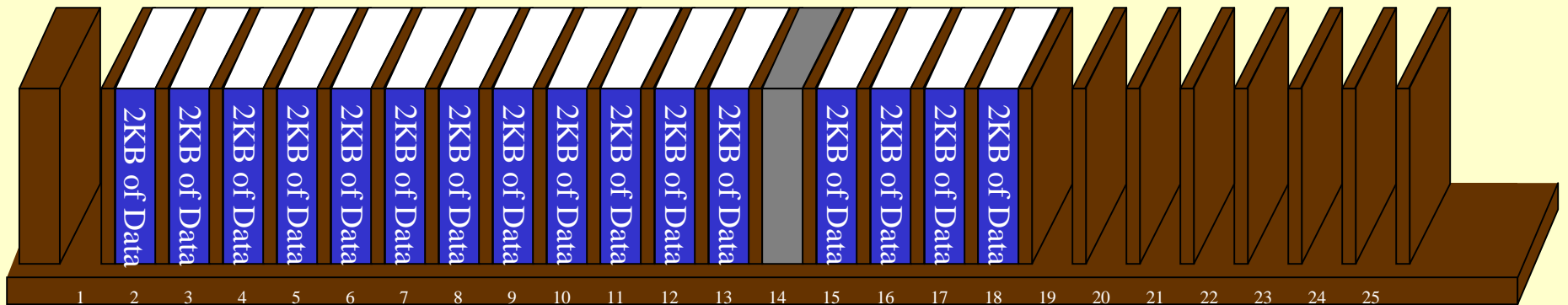
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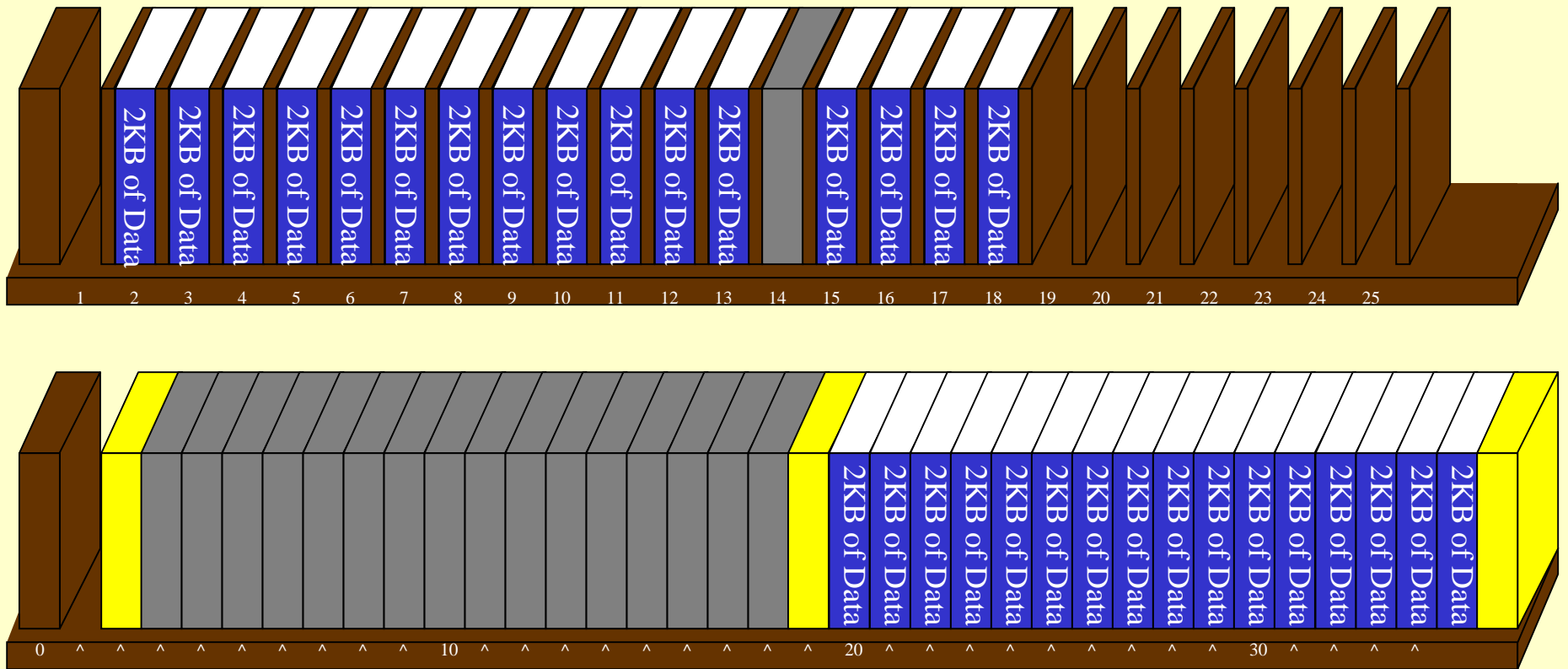
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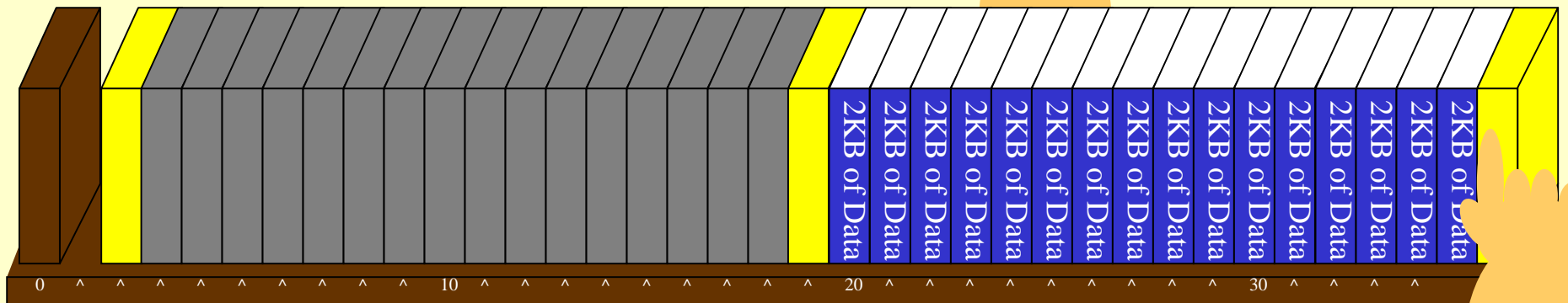
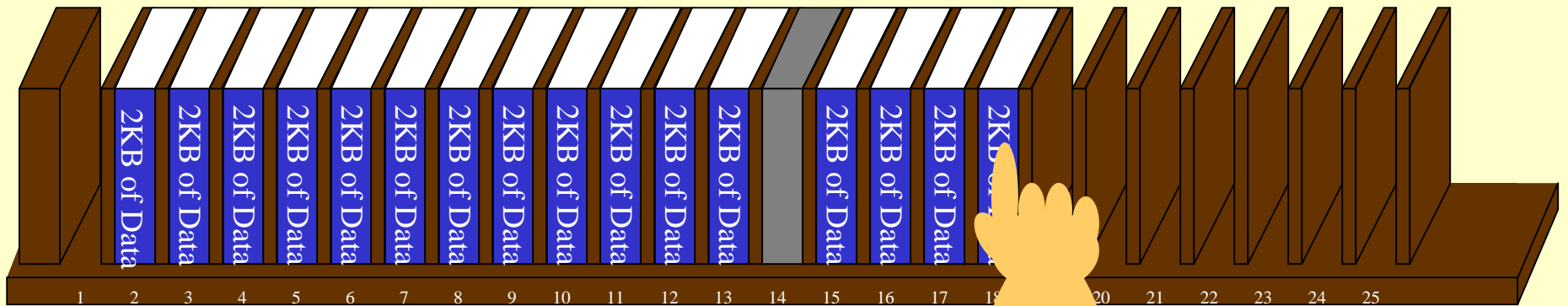
# Defect Management

Deflect Management: Also highlights the advantage of the DVD-RAM format. DVD-RAM allows data to be handled in much smaller packets making it 16 times as efficient.



# Defect Management (continued)

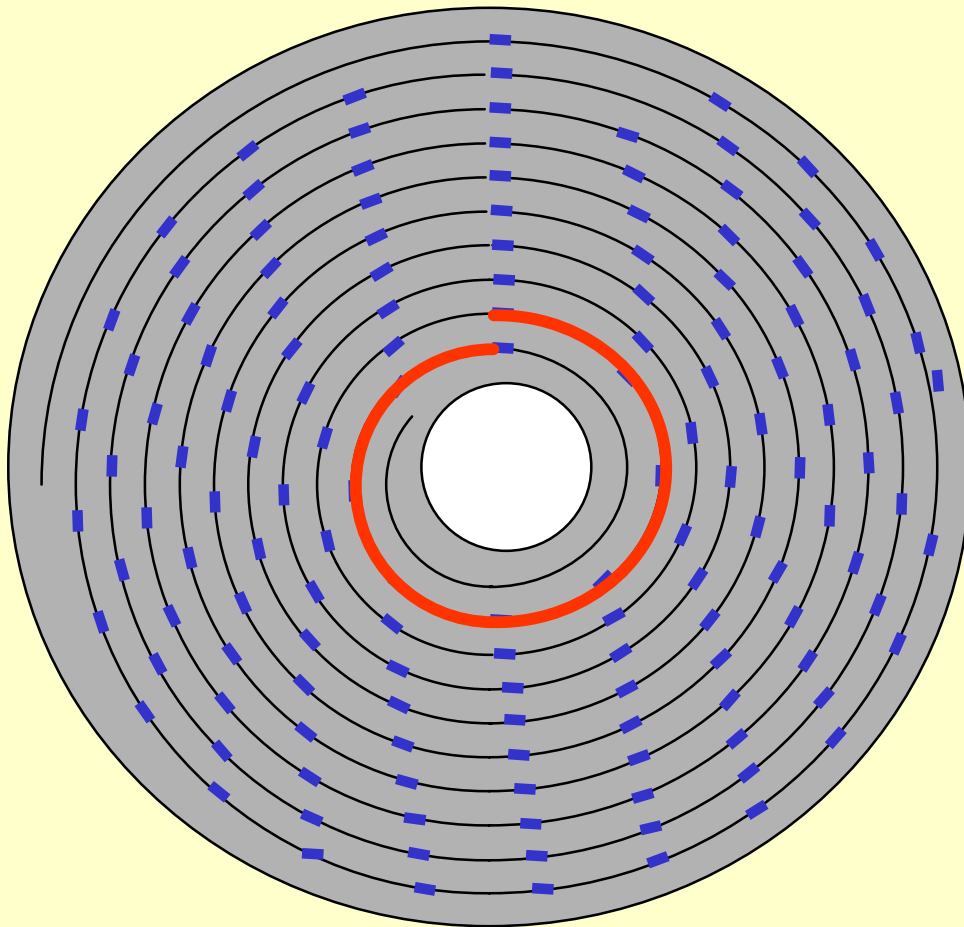
As a result of the efficient defect management, DVD-RAM can have much faster data transfer rates.



# Defect Management (continued)

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A method to describe track layout

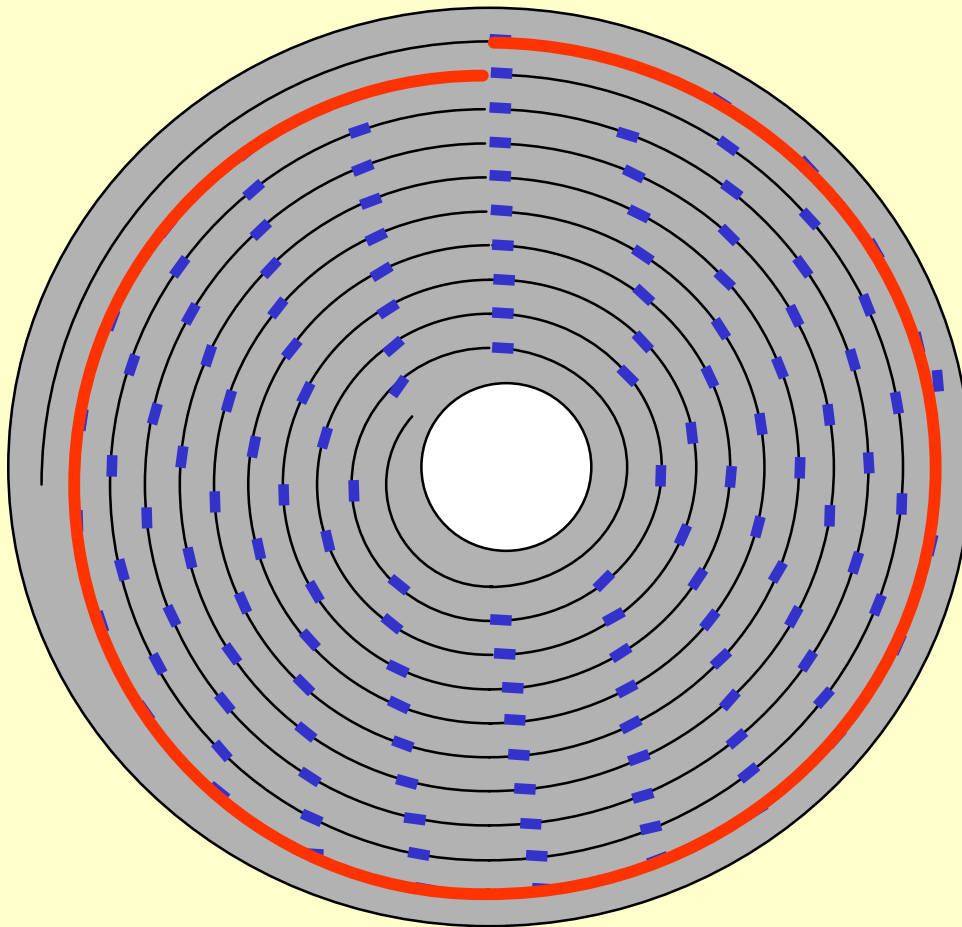


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# Defect Management (continued)

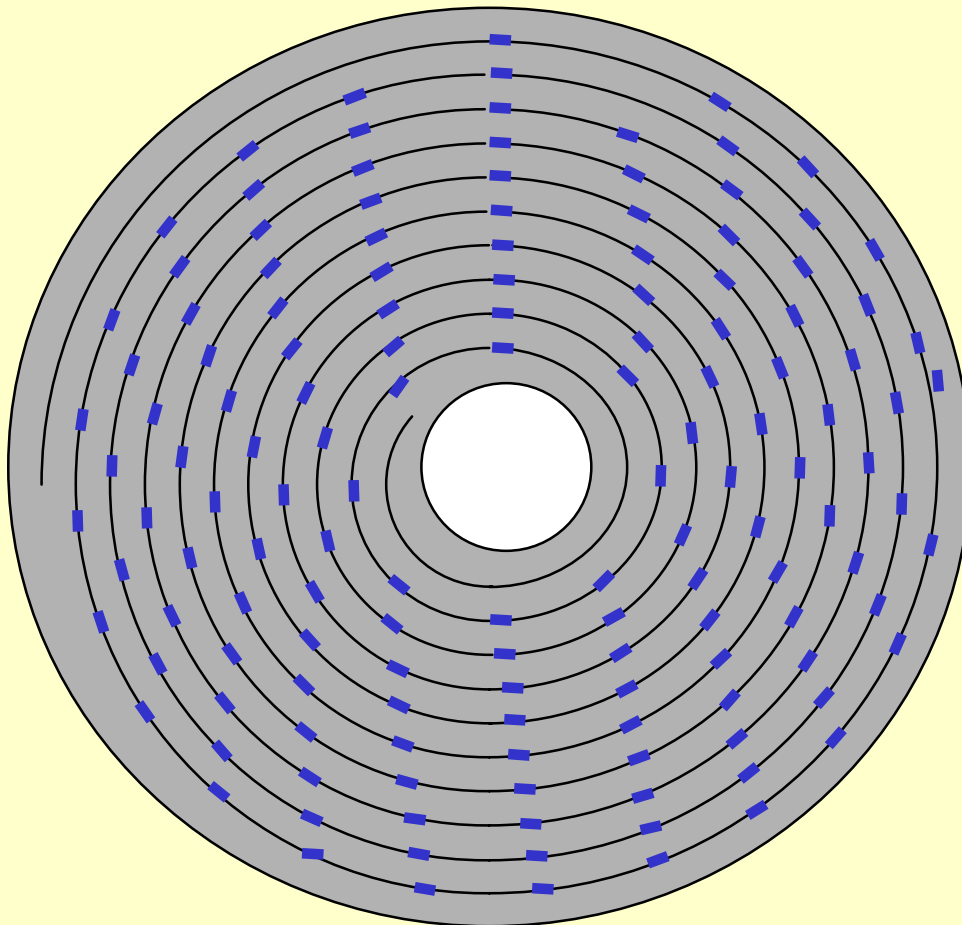
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A method to describe track layout

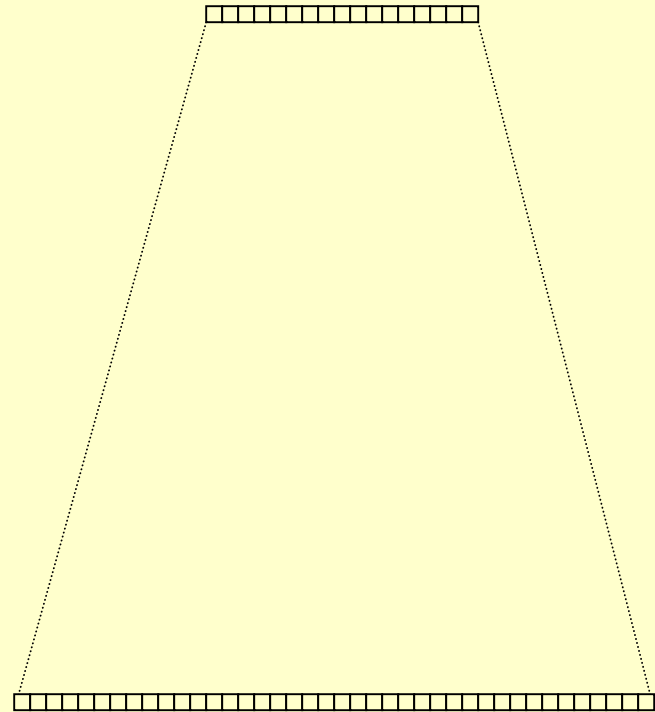


# Defect Management (continued)

A method to describe track layout



17 physical sectors per track

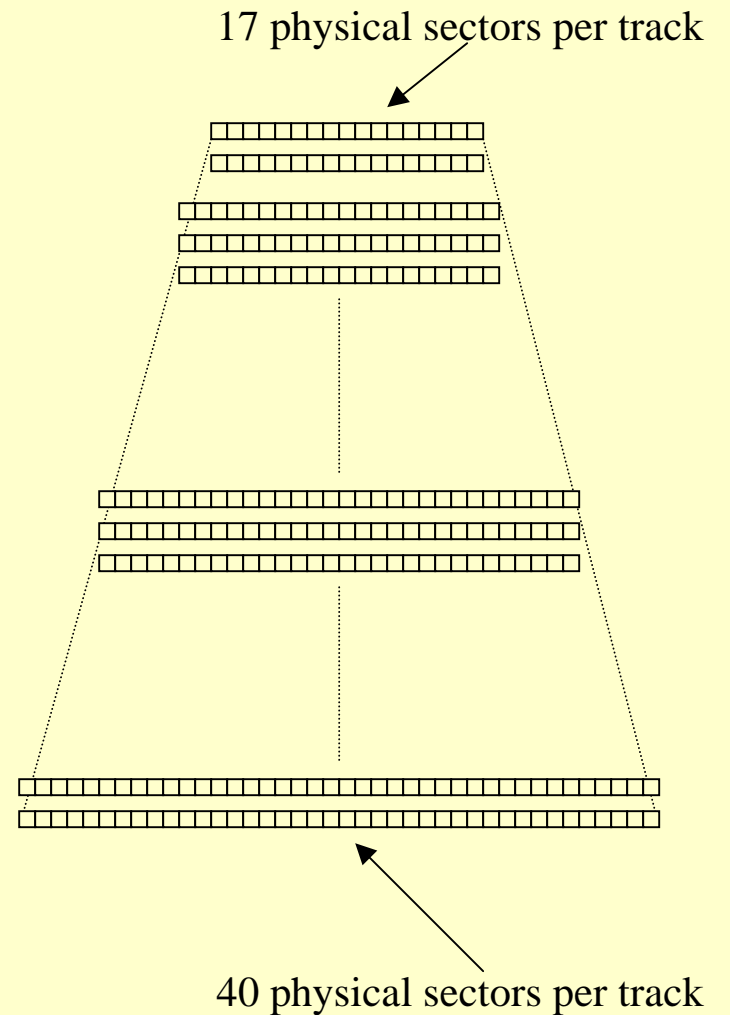
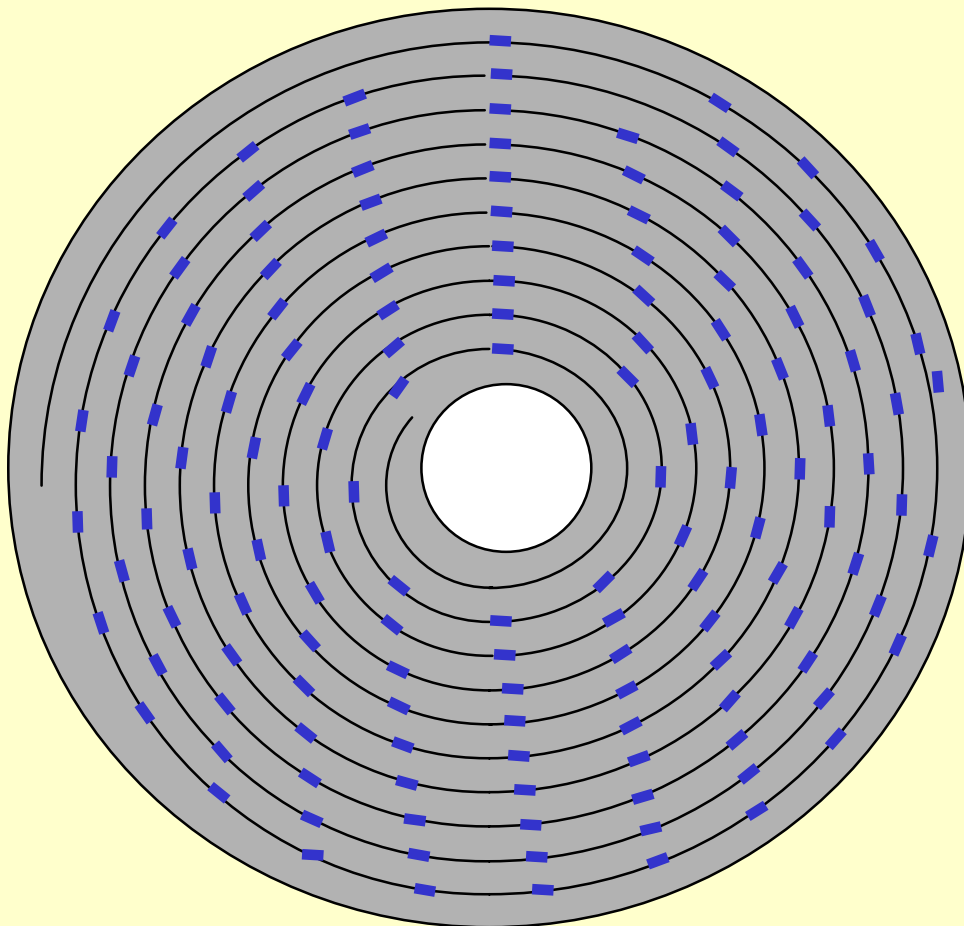


40 physical sectors per track



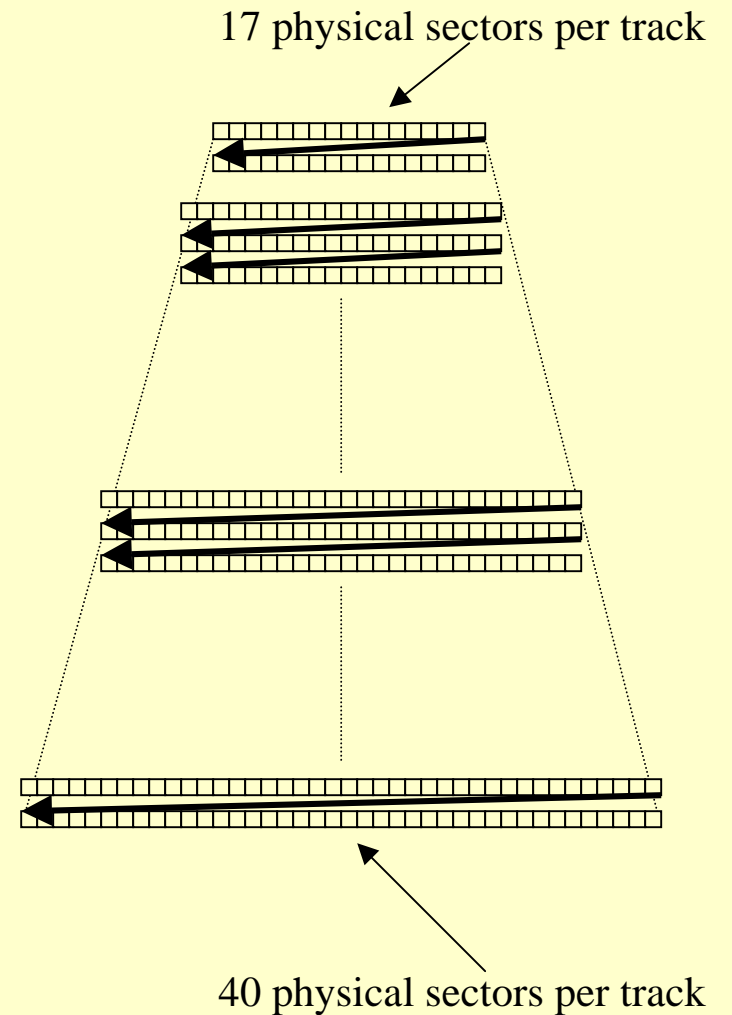
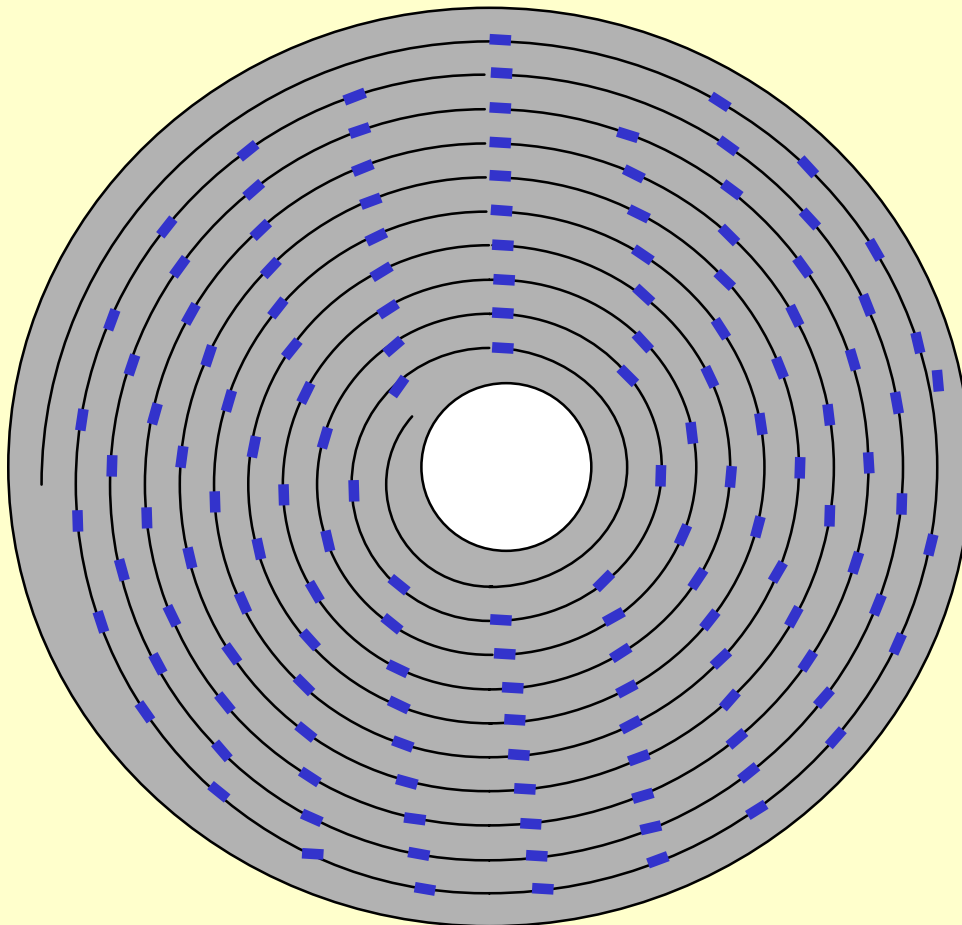
# Defect Management (continued)

A method to describe track layout



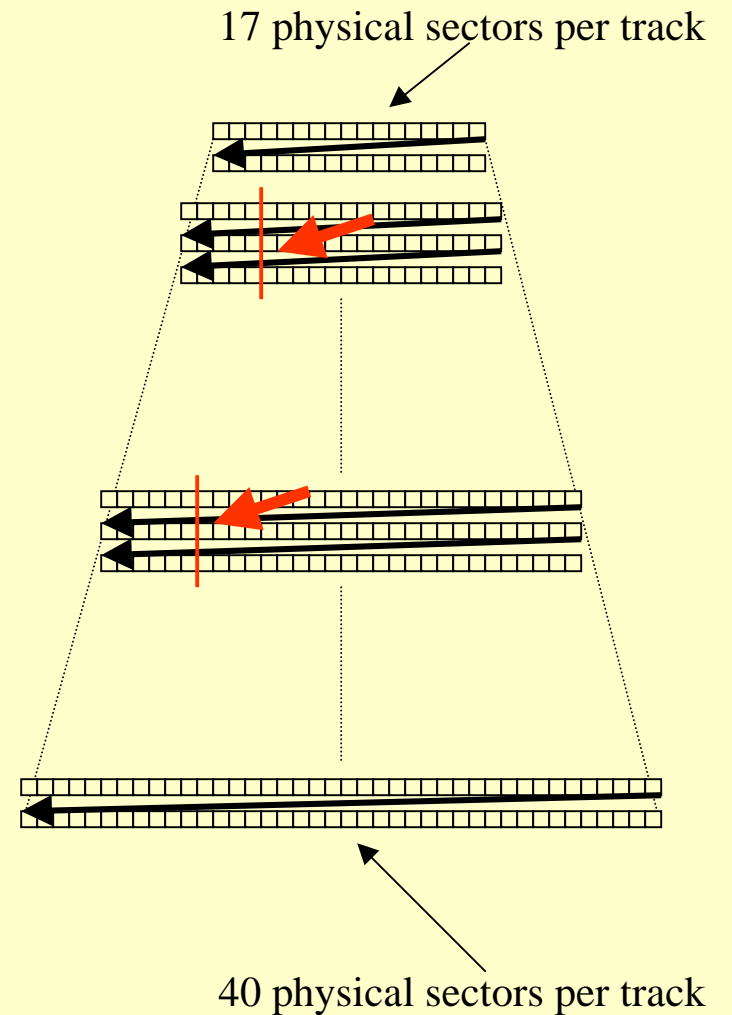
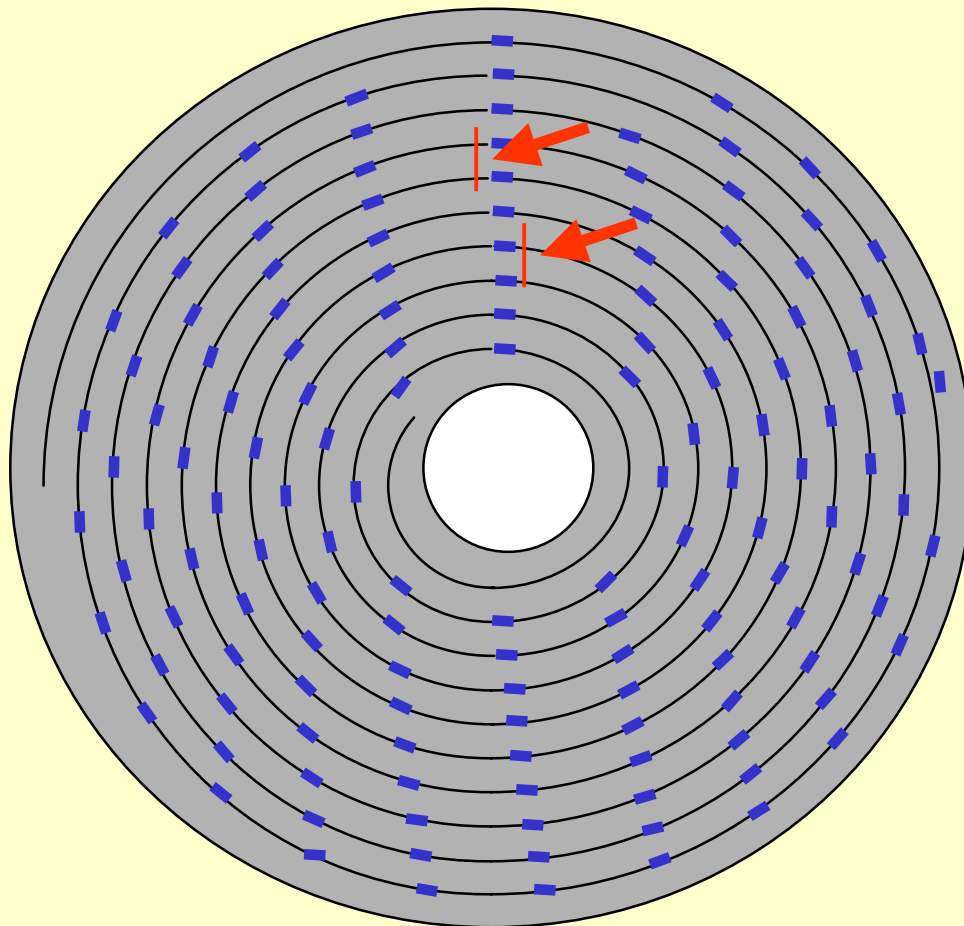
# Defect Management (continued)

A method to describe track layout



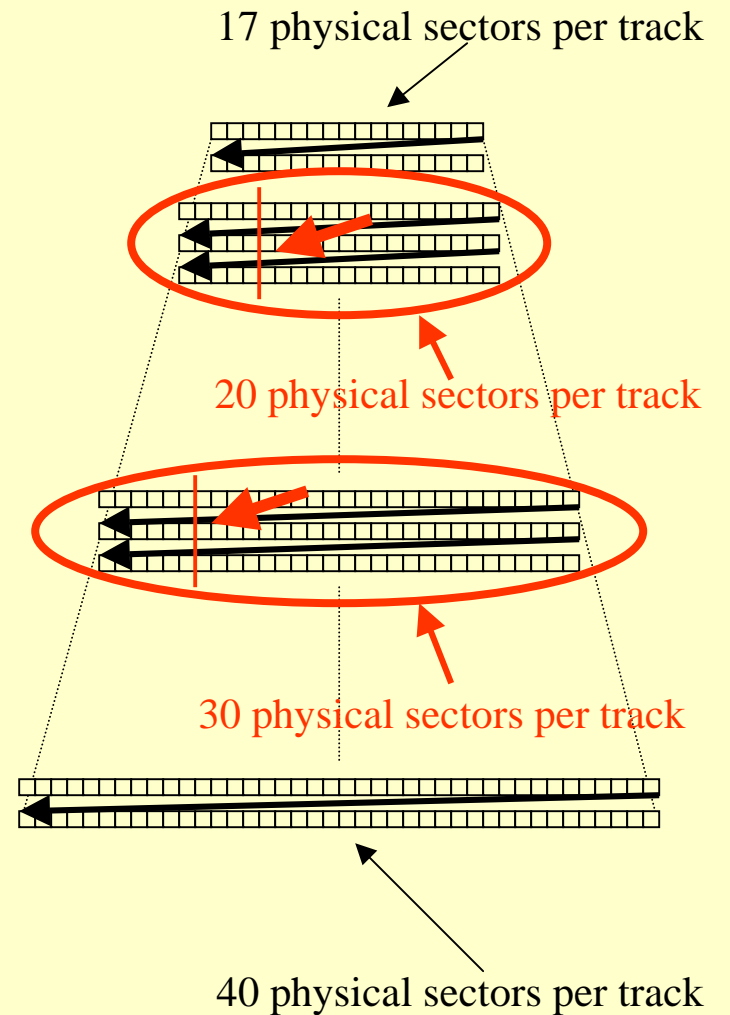
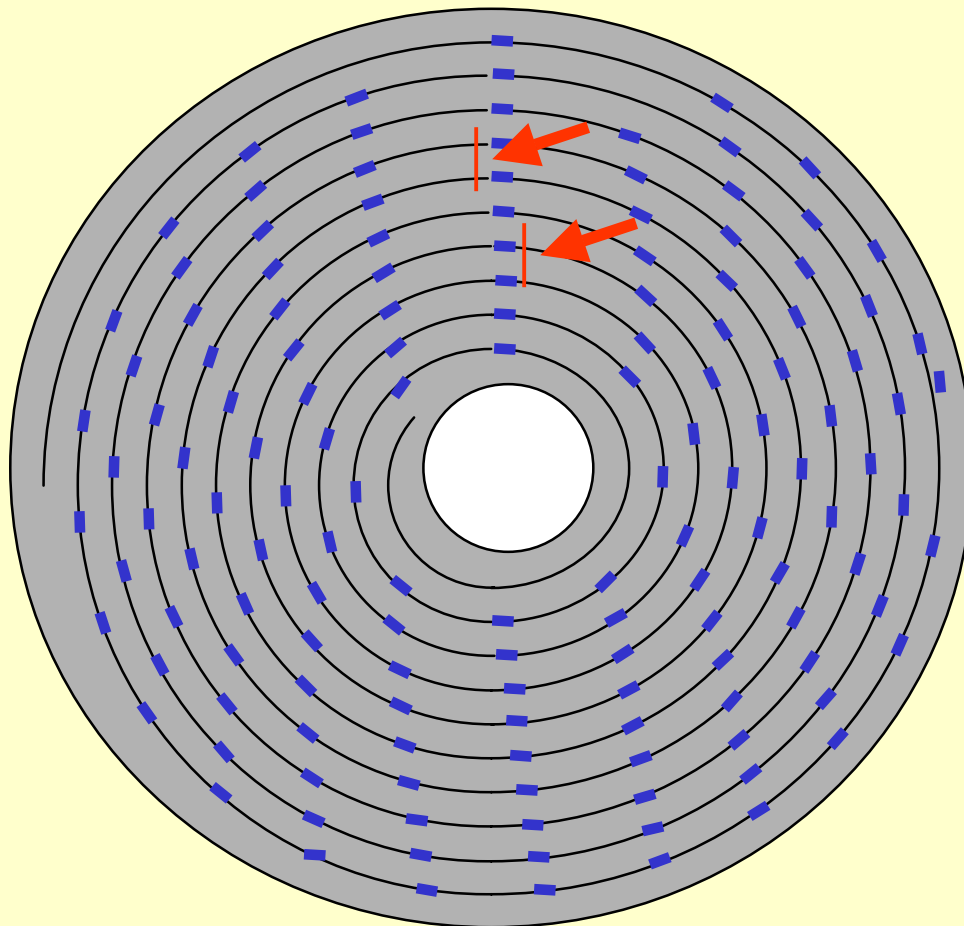
# Defect Management (continued)

A method to describe track layout



# Defect Management (continued)

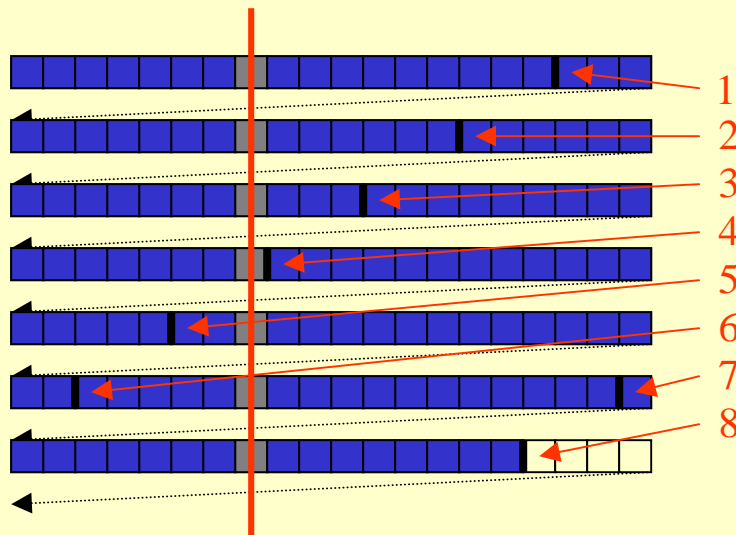
A method to describe track layout



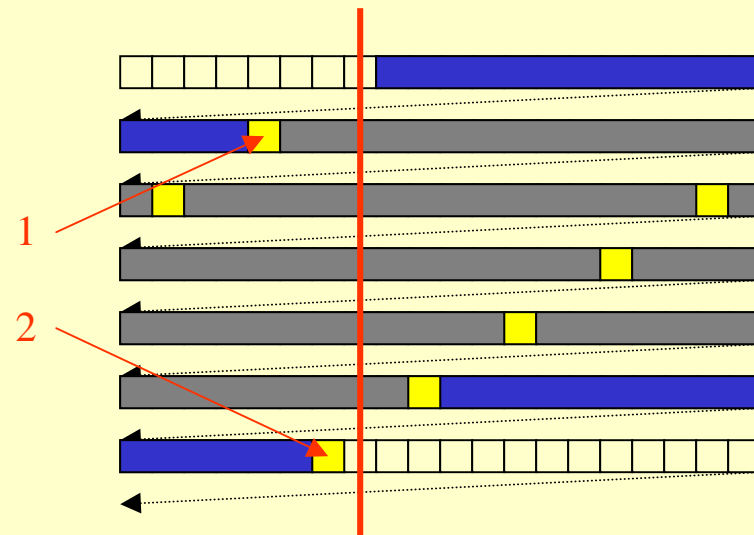
# Defect Management (continued)

Example: 20 physical sectors per track

2 KB Blocks (DVD-RAM)



32 KB Blocks



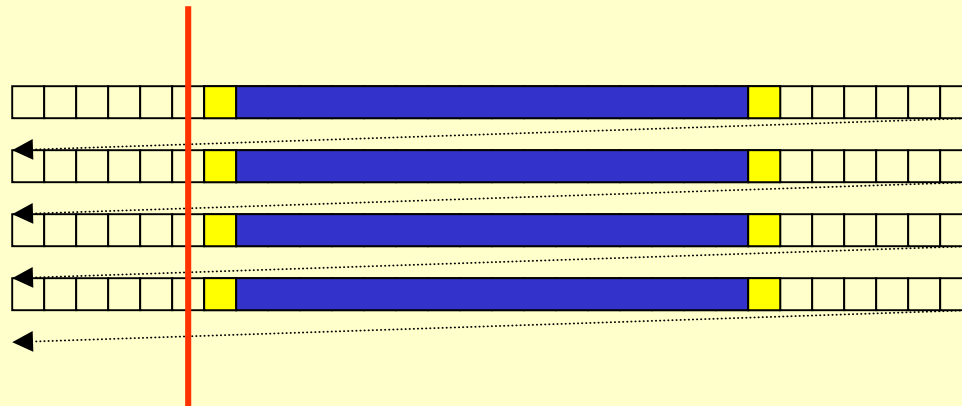
The DVD-RAM format prevents loss of storage capacity



# Defect Management (continued)

Example: 30 physical sectors per track

32 KB Blocks



The DVD-RAM format ensures a high data transfer rate.

Data rate is no less than 10.5 megabits per second

If data is handled in 32 KB blocks:

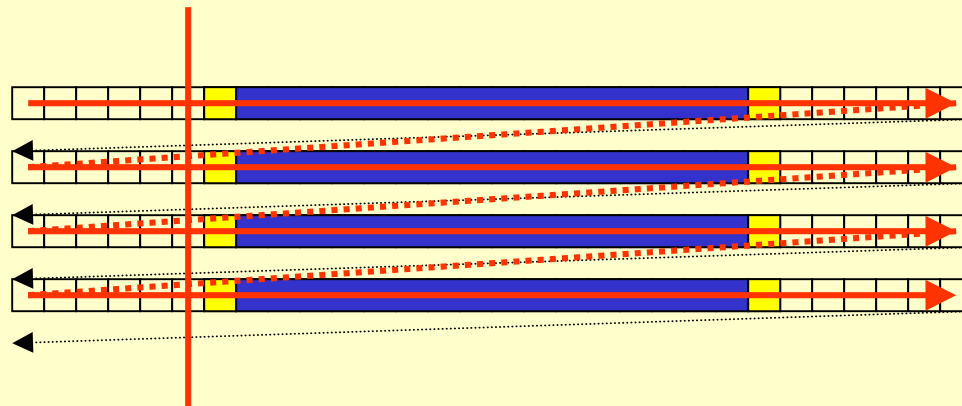
Data rate can drop to 5.9 megabits per second



# Defect Management (continued)

Example: 30 physical sectors per track

32 KB Blocks



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Data rate is no less than 10.5 megabits per second

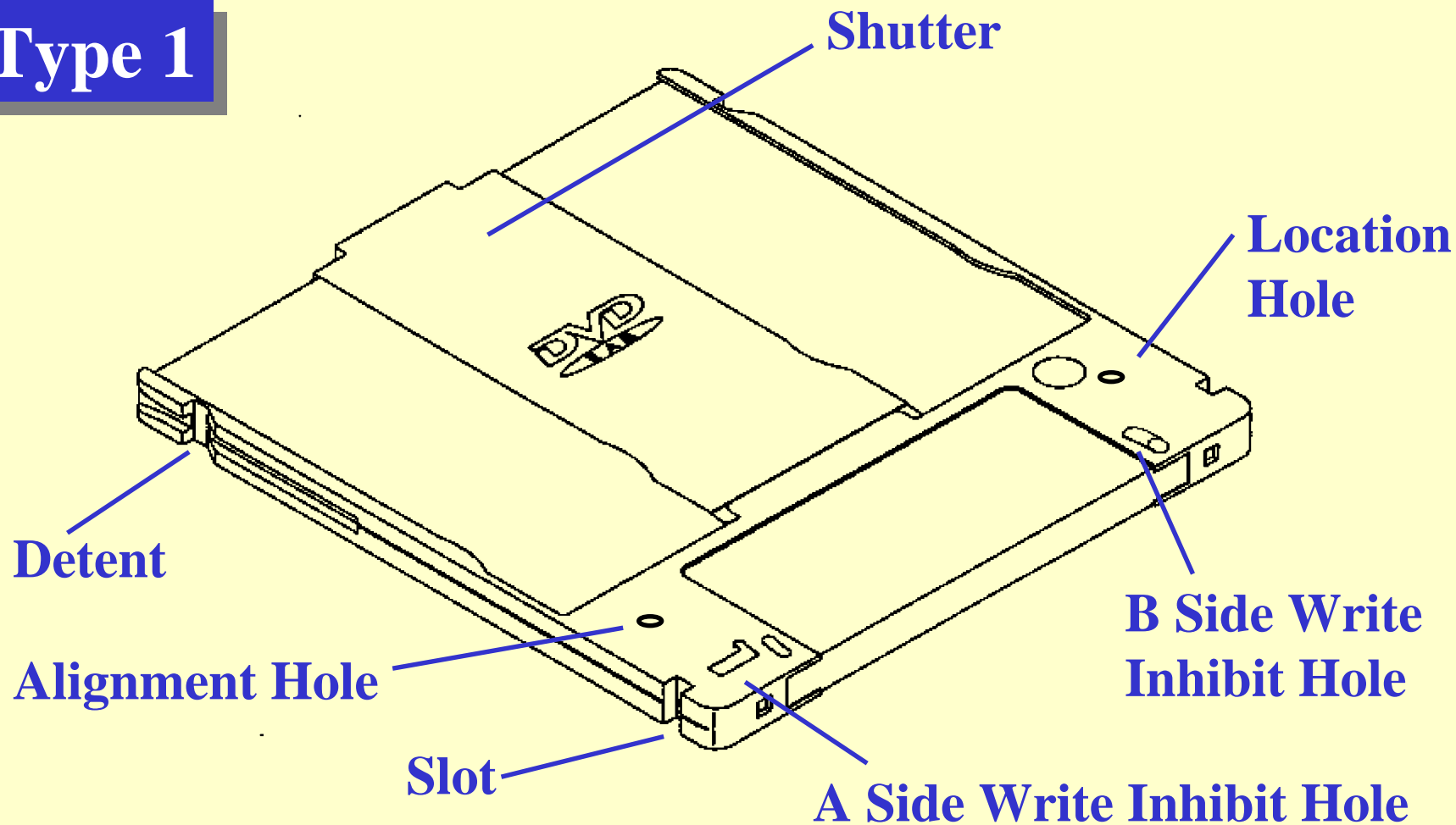
If data is handled in 32 KB blocks:

Data rate can drop to 5.9 megabits per second



# DVD-RAM Cartridge

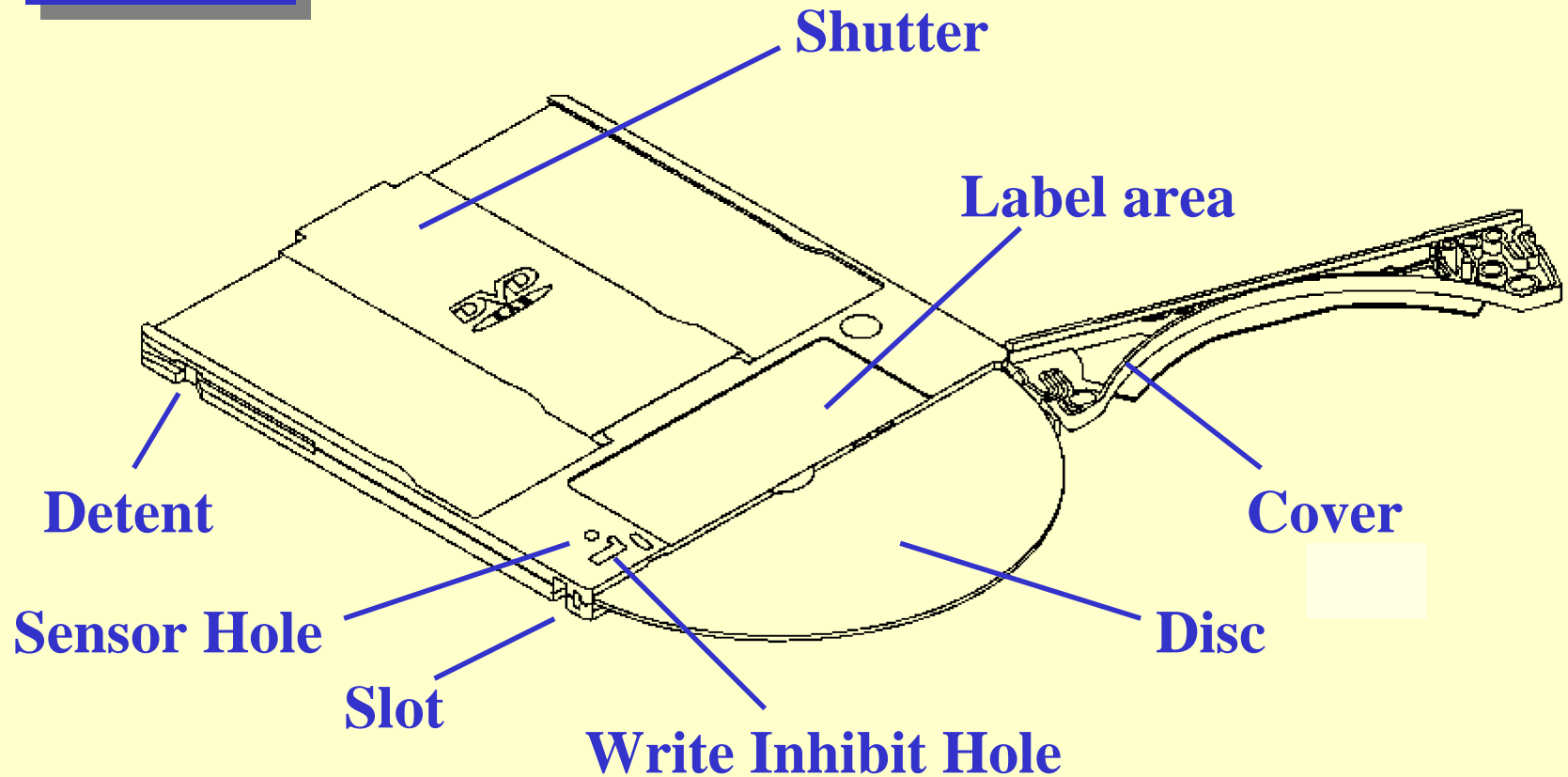
**Type 1**



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# DVD-RAM Cartridge (continued)

## Type 2



# DVD-RAM Advantages

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High address reliability

Addressing errors: less than  $10^{-23}$

Strong Error Recovery

2 KB physical sector size ensures reliability of ECC

Fast Data Transfer Ensured

Data transfer rate is 10.5 Mb/s or greater

Superior Data Protection

Cartridge to protect media



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# Current DVD-RAM Opportunities

## DVD-RAM Application Advantages

Protects data investment: Reads all CD and DVD Formats

Brings high capacity: 2.6 GB per side, 5.2 GB per disc

Lowest cost rewritable random access media: < \$ 0.01 per MB  
2.6 GB media: \$25 5.2 GB media: \$40

## Application Opportunities

Multimedia Development

Data Backup and Archiving

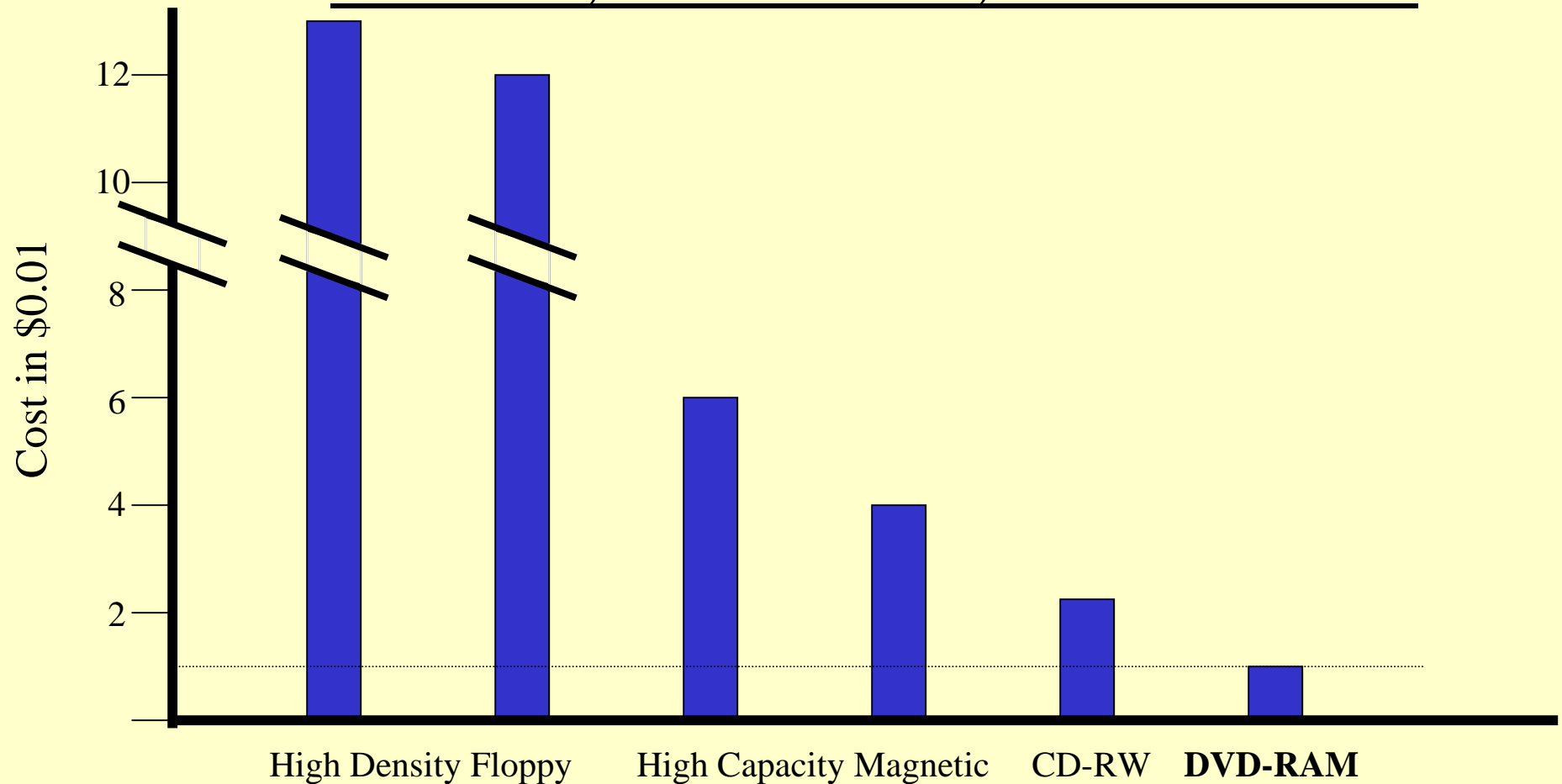
Network Storage and Data Transfer



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# Comparison of Data Storage Media

## Cost Per Megabyte for Different Types of Rewritable, Random Access, Removable Media



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# Current Opportunities (continued)

Some companies developing applications with support for DVD-RAM:

<b>Hbourne Group</b>	Audio, video, production systems
<b>LaCie</b>	End-user PC, Mac, DVD-RAM storage subsystem
<b>NSM Jukebox</b>	DVD jukeboxes
<b>Plexus</b>	Knowledge management, workflow solutions
<b>Prassi Software USA</b>	DVD development, production software
<b>Seagate Software</b>	Backup, disaster recovery software
<b>Sigma Designs</b>	MPEG, digital video board products
<b>Smart Storage</b>	Storage system software
<b>Software Architects</b>	On-line file system DVD-RAM support
<b>Sonic Solutions</b>	DVD Authoring, real-time MPEG-2 Encoding, and Digital Audio Solutions
<b>Trace Technologies</b>	WinNT, UNIX, jukebox management software



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# Importance of DVD-ROM

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## DVD-ROM

Low Cost Application Distribution

Low Cost Data Base Distribution

High Quality Games & Interactive Titles

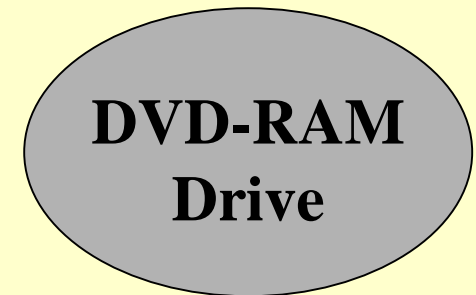
DVD Movies

## DVD-RAM

Multimedia Development

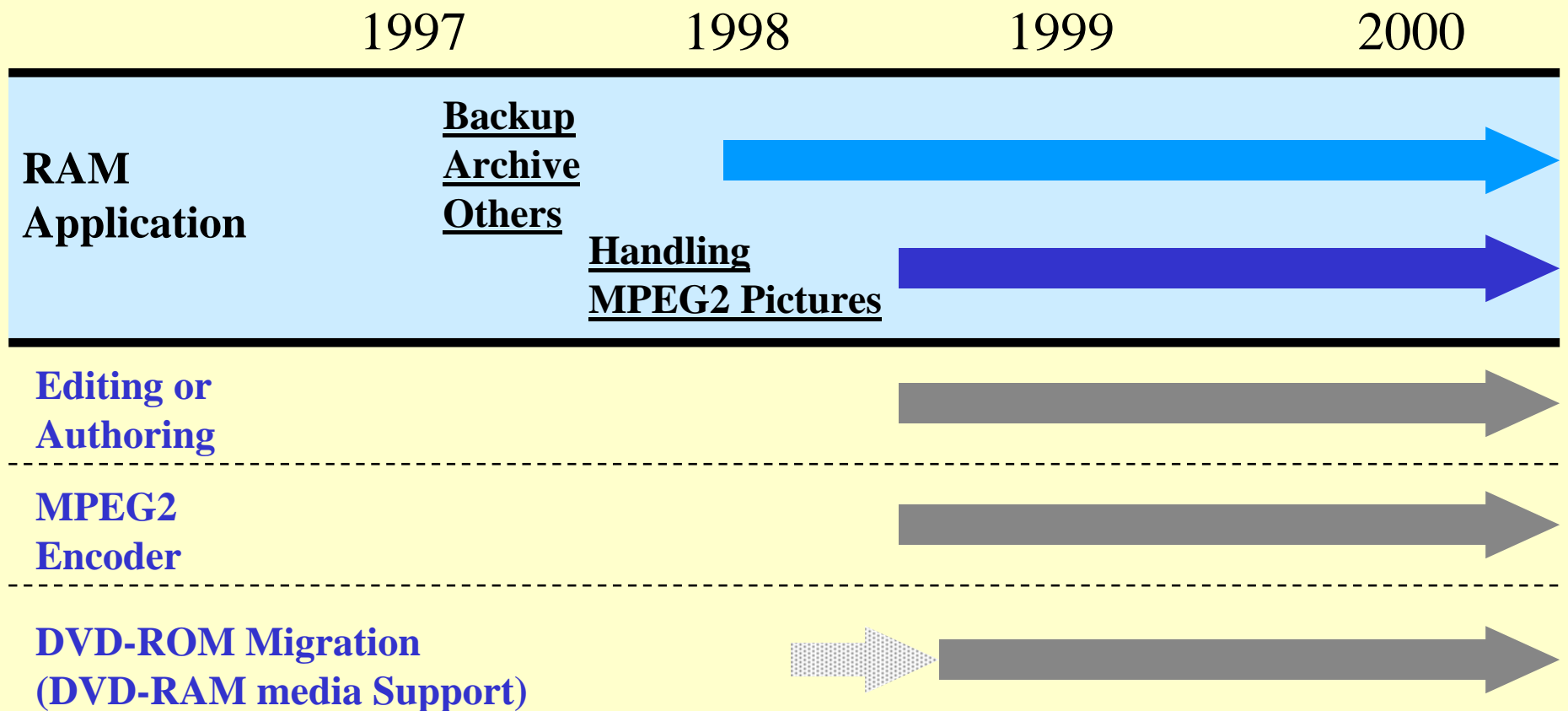
Data Backup and Archiving

Network Storage and Data Transfer



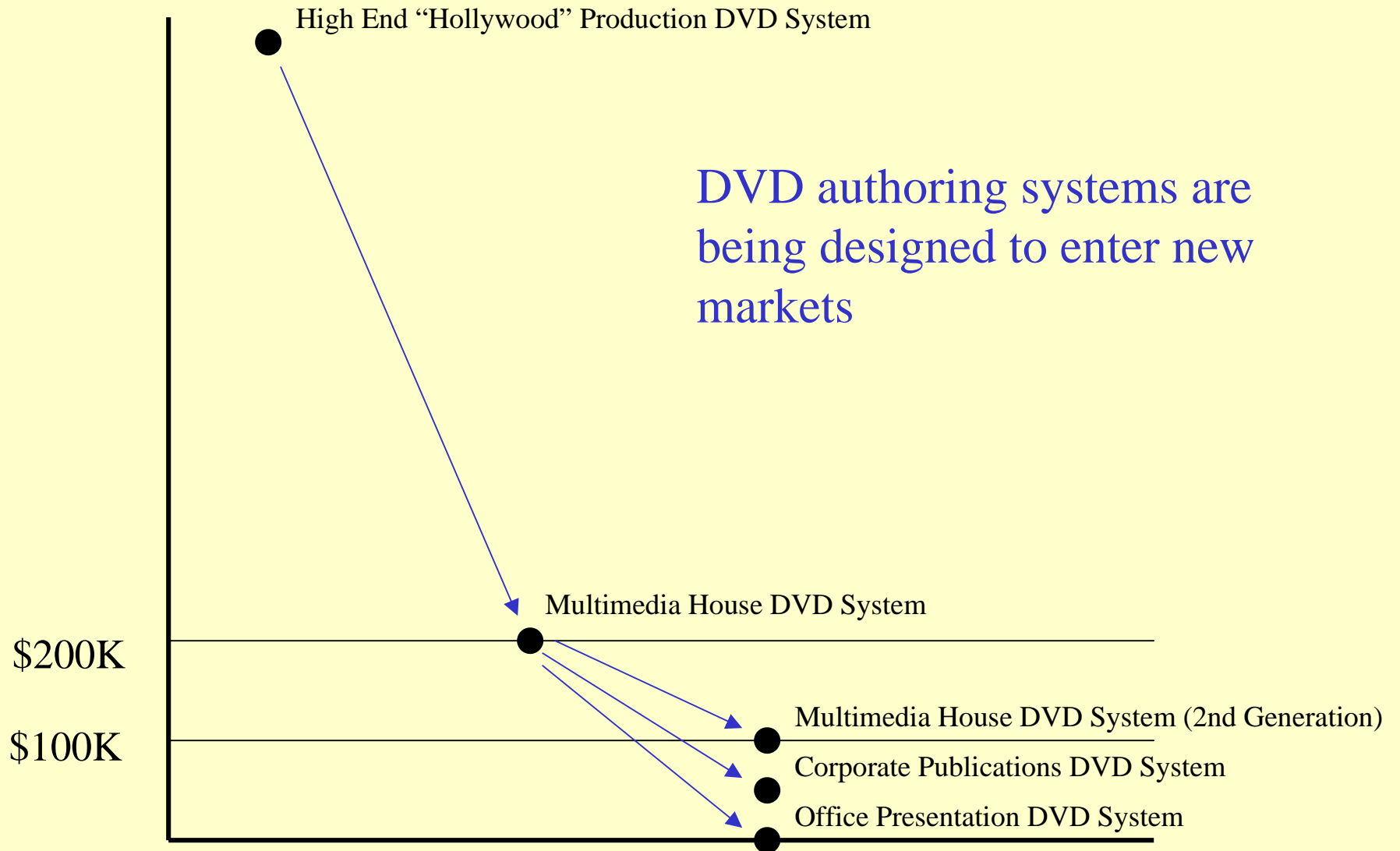
# Future DVD-RAM Opportunities

New technologies are being developed to enable the use of MPEG-2 video in new commercial and home applications.



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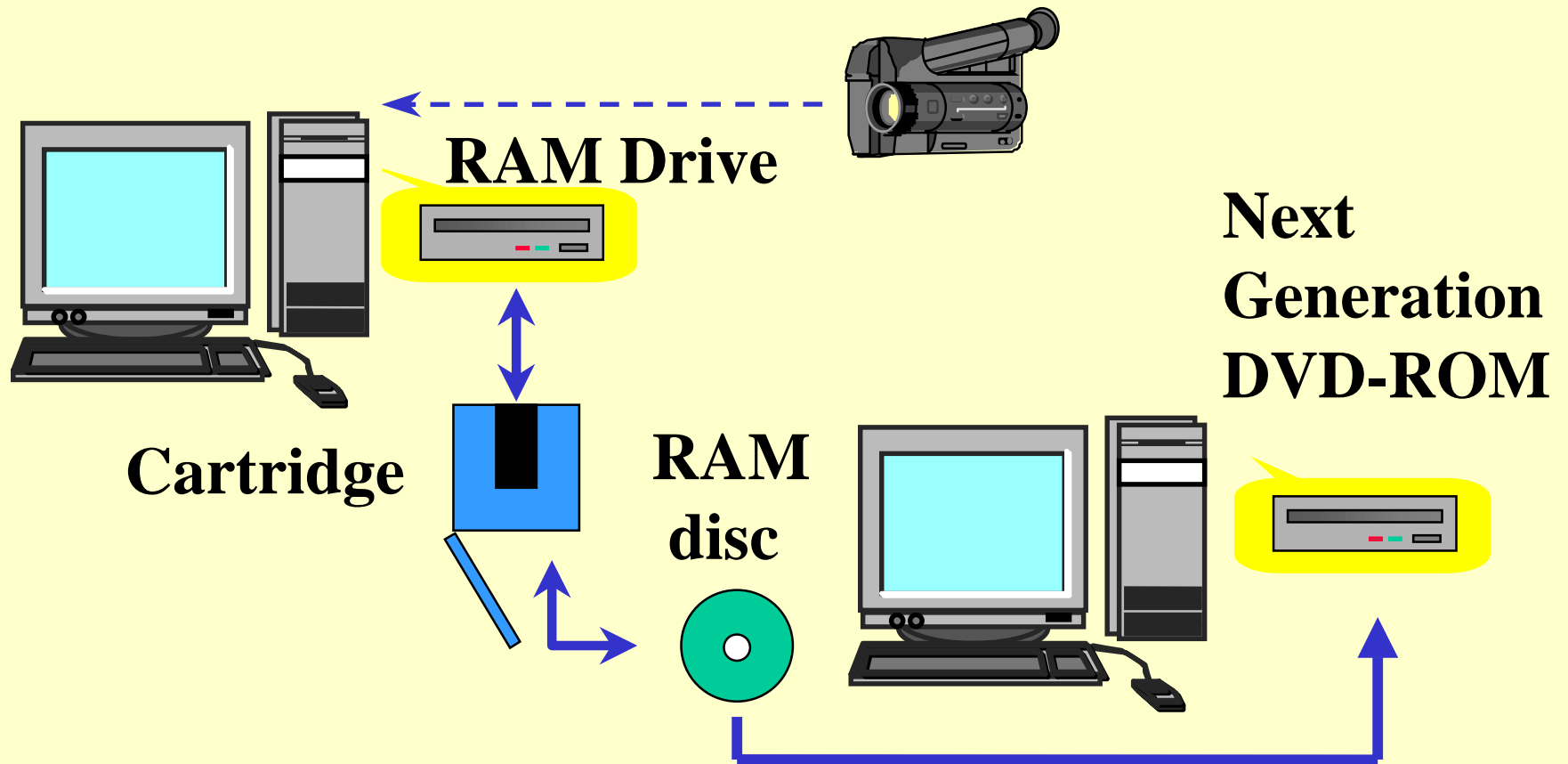
# DVD-RAM Opportunities (continued)



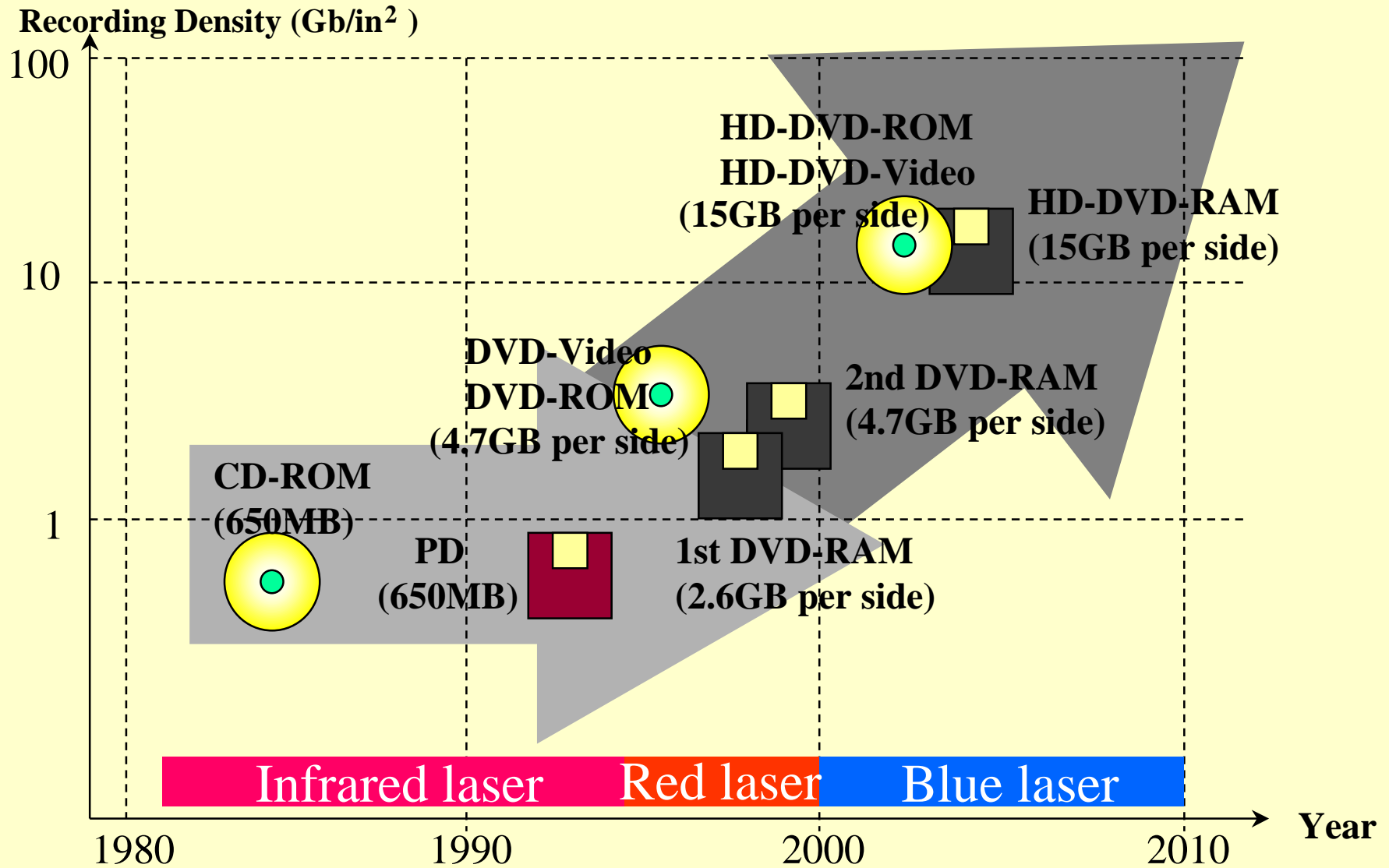
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# DVD-RAM Opportunities (continued)

The DVD enabled PC will be the playback platform for commercial applications with MPEG-2 video.



# Future DVD-RAM Developments



# DVD-RAM Developments (continued)

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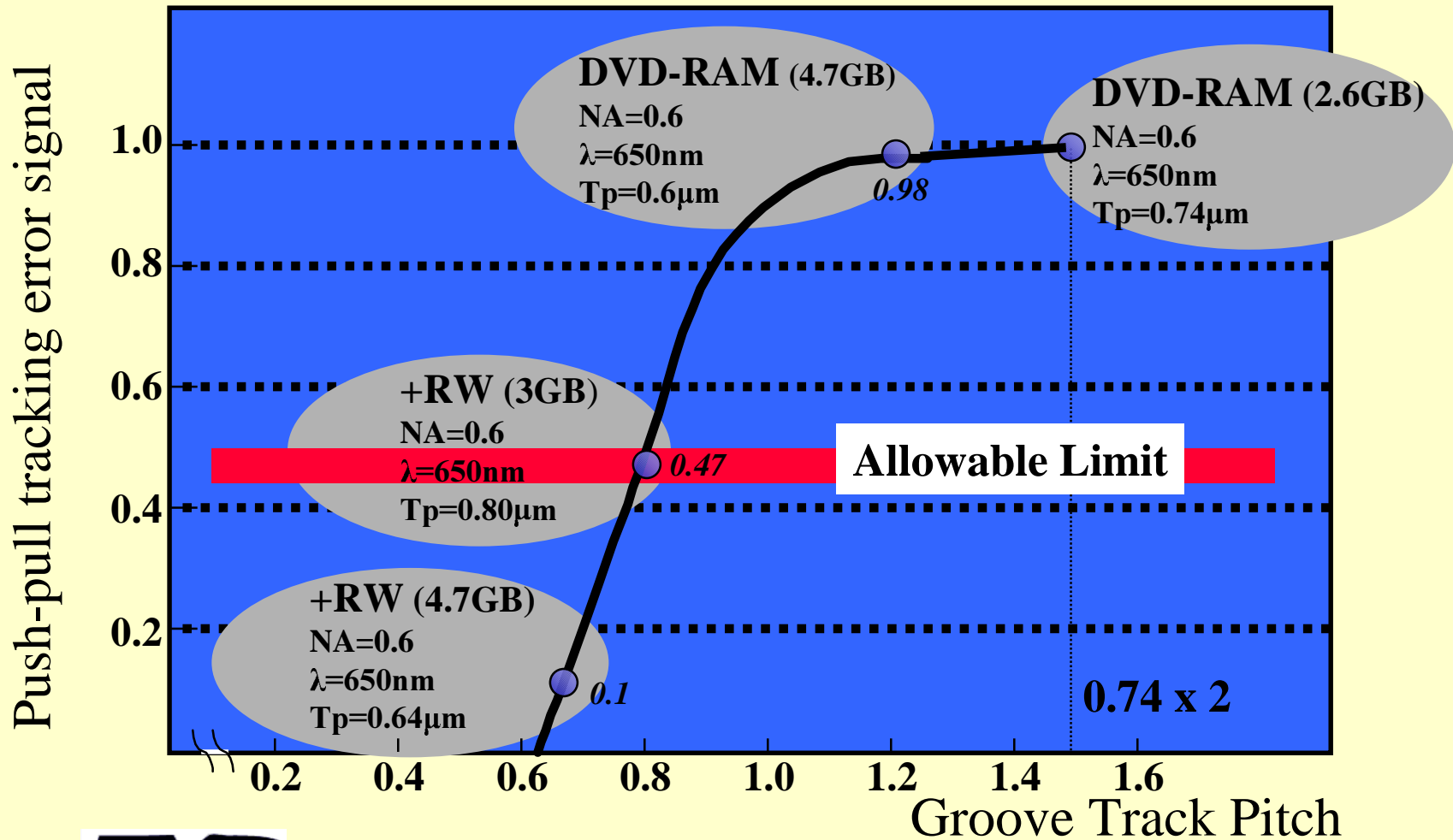
**Feasibility of 4.7 GB per side has been confirmed on DVD-RAM:**

- **Track pitch:**  
0.6 um ... possible with wobbled Land & Groove technology
- **Bit Pitch:**  
0.28um ... possible with higher signal to noise media
- **Experimental Condition:**  
Laser wavelength 650nm, Numerical Aperture 0.6



# DVD-RAM Developments (continued)

Normalized tracking error signal versus groove track pitch



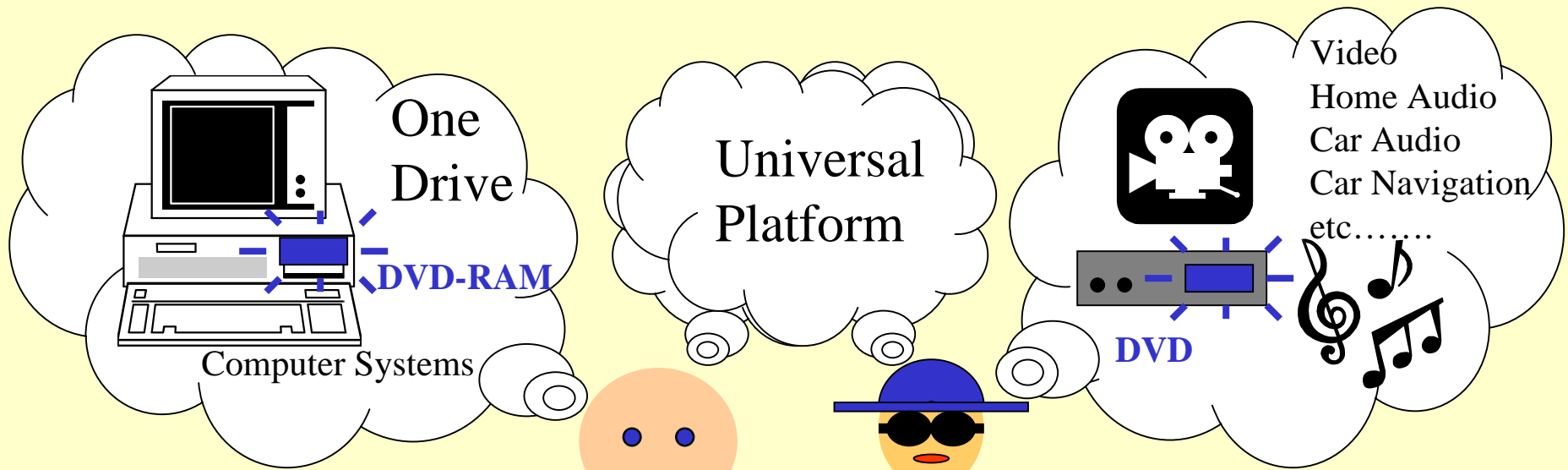
# Additional DVD Activity

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- Copy Protection Management
- Watermarking methods
- DVD Audio

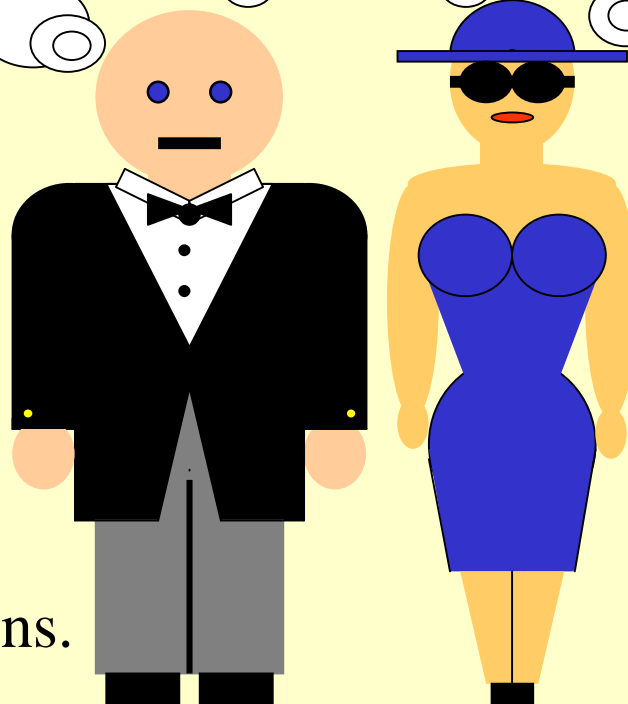


# Digital Convergence



## DVD-RAM

provides the best opportunity for the marriage of consumer and computer applications.



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# DVD-RAM Summary

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## Superior Format

- High address reliability
- Strong Error Recovery
- Fast Data Transfer Ensured

## New Application Opportunities

- Protects data investment
- Brings high capacity
- Lowest cost rewritable random access media
- Media to support new video applications

## Stable Future

- Upward migration path with backward compatibility

