



# Software Development Seminar

CD-ROM (Basic)



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# CD-ROM Basic Overview

## LibCD Overview



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# CD-ROM Basic Overview

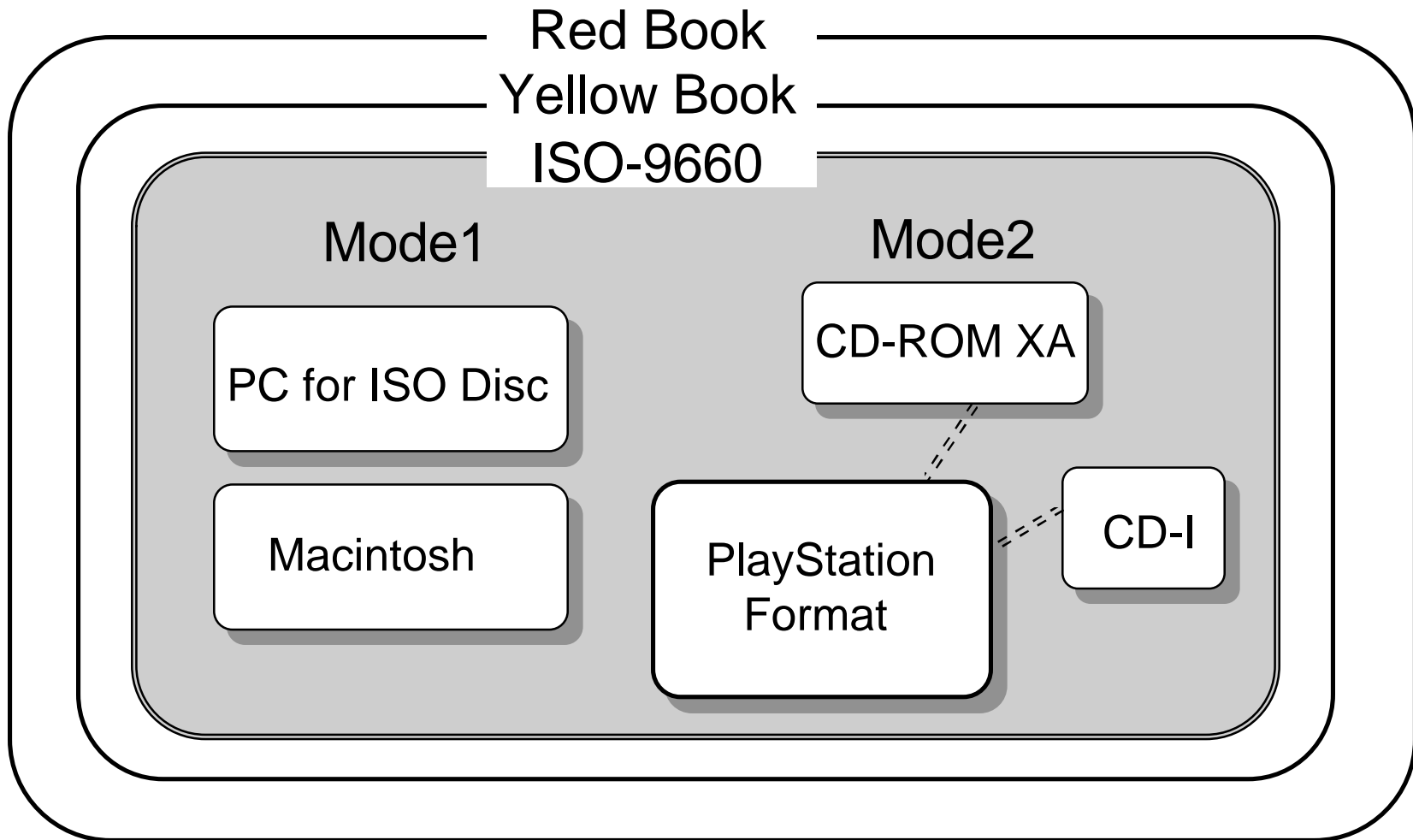


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# Relationships between CD-ROM formats



## Relationships between CD-ROM formats (cont)

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### **Red Book**

Describes the format of an audio CD

### **Yellow Book**

Specification for the storage of Digital Data on a CD (Compact Disc)

### **ISO-9660**

Describes the directory structure for configuring the filesystem

### **CD-I**

Describes the OS including the graphic system for playing data, audio, graphics, etc.

### **CD-ROM XA**

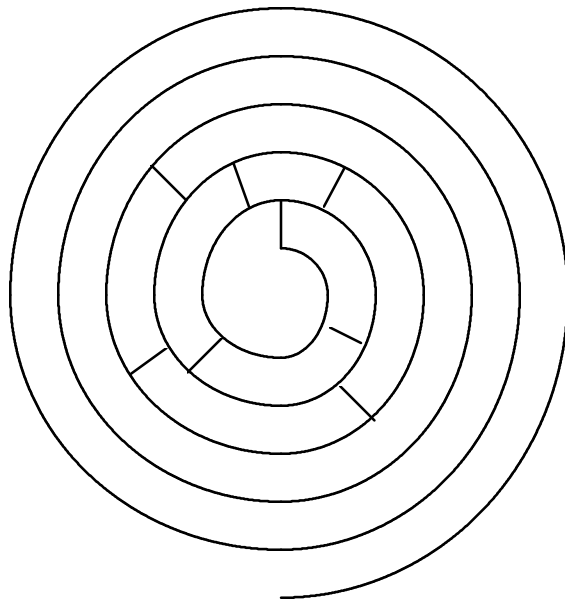
Describes real-time data of audio and graphics

The PlayStation format conforms to ISO-9660

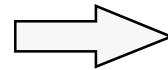
The PlayStation format is not compatible with what is technically in common with CD-I and CD-ROM XA



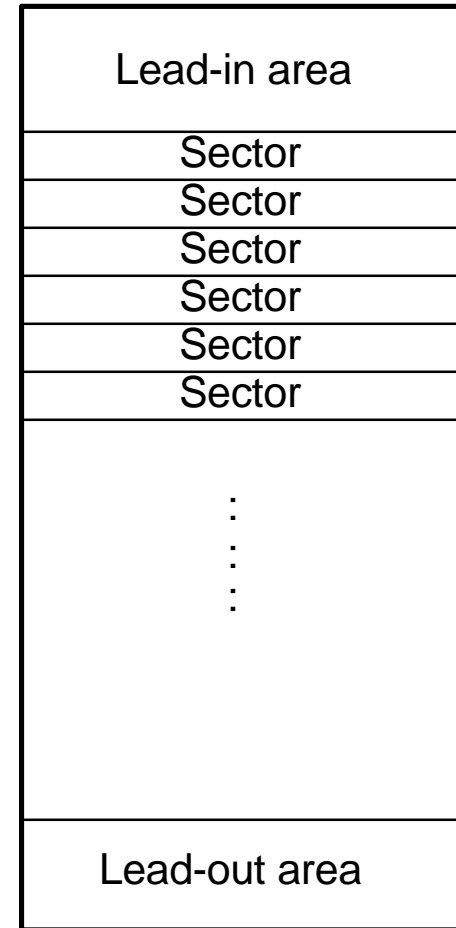
# Data layout



Fixed length sectors are arranged in a spiral



Innermost track



Outermost track



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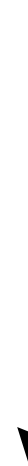
# Sector address

- Minute: second: specified in the sector
- One second = 75 sectors
- Immediately after Lead-in, the first sector is 00:00:00

time(ATime) lead-in area

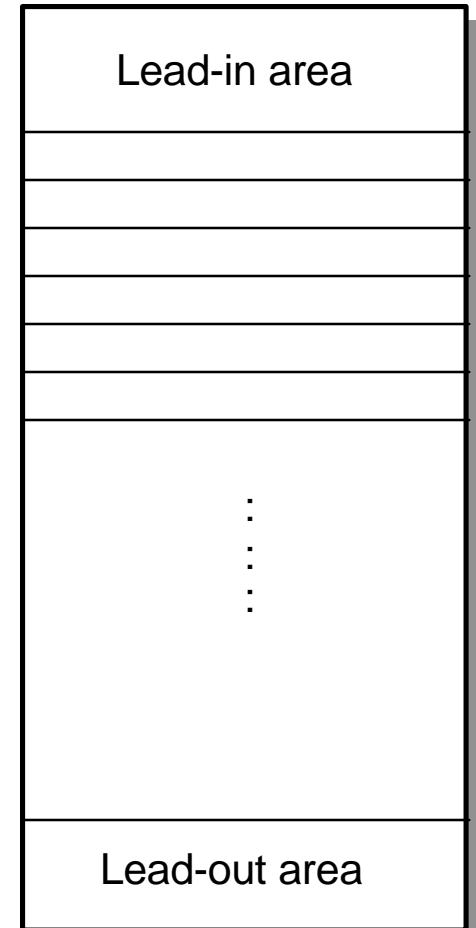
(minute: second: sector)

00:00:00  
00:00:01  
00:00:02



70:59:74  
(Max.)

Innermost track



Outermost track

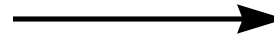


# Sector type

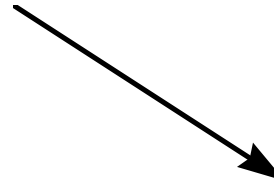
---

- DATA

program  
graphics/movie data  
others, general data



Mode2/Form1  
data sector



- ADPCM

compressed audio data



Mode2/Form2  
data sector

- CD-DA

same as audio CD  
44.1 KHz 16-bit PCM data



CD-DA sector



# Structure of separate type sectors

Data :Mode2/Form1

ECC corrected data

SYNC (12)	Header(4)				Sub Header(8)	User Data (2048)	EDC (4)	ECC (276)
	Min	Sec	Sector	Mode				

Data :Mode2/Form2

No ECC correction

Audio data, etc. from interpolation

Used in played back data

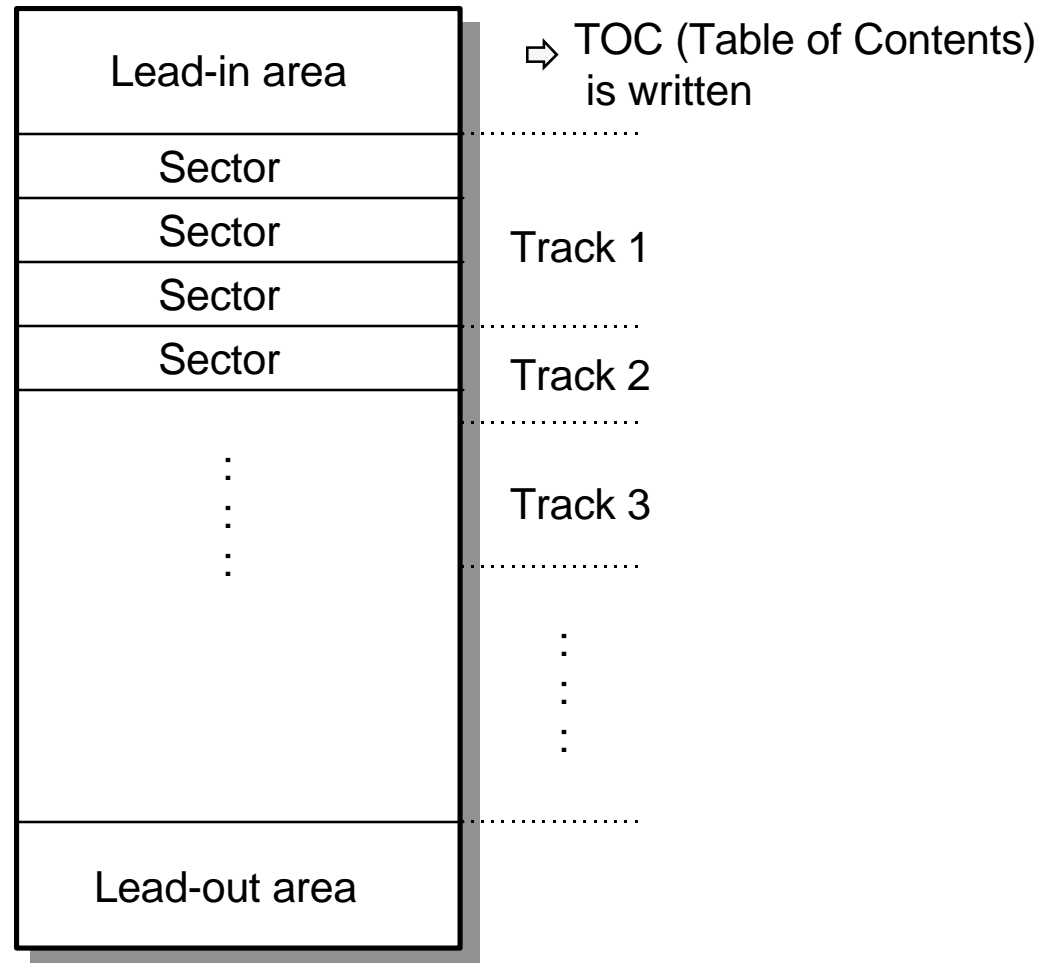
SYNC (12)	Header(4)				Sub Header(8)	User Data (2324)	zero or EDC(4)
	Min	Sec	Sector	Mode			

CD-DA

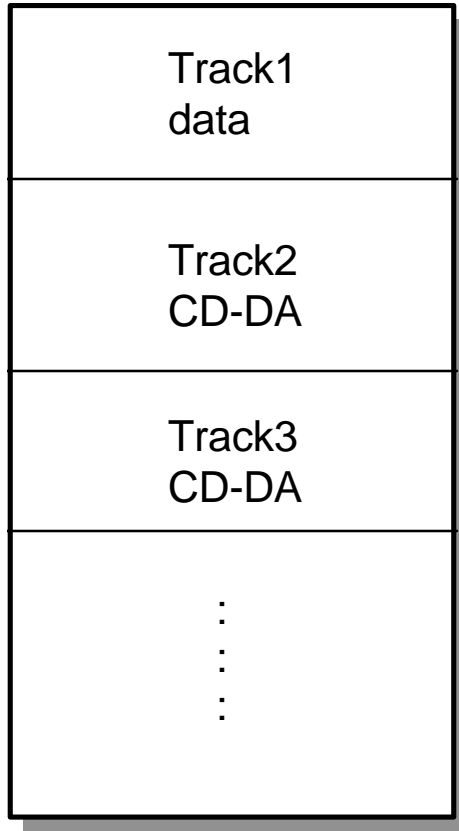
Audio Data (2352)
-------------------



# Track structure



## Track structure (cont)



⇒ Lead track  
data track  
ISO-9660 filesystem

Note: The track must be CD-DA  
starting with track 2



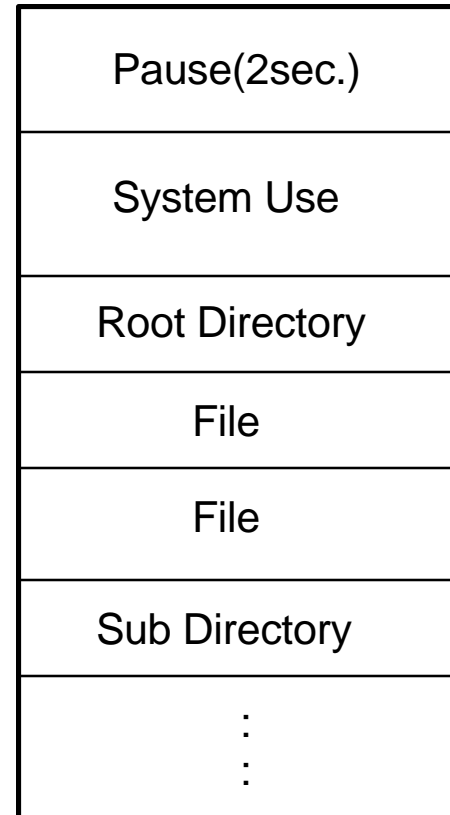
# ISO-9660 filesystem

---

Supports hierarchical directory  
30 files / directory in LibCD

Each file is laid out continuously  
pointing to the start location only

Track1



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## ISO-9660 filesystem (cont)

---

- System Area  
Stores license data
- Primary Volume Descriptor  
Maintains various types of information like  
disk name and author
- Path Table  
Maintains the location of each subdirectory  
within the disk



# System area

---

- The system area is a fixed group of 16 sectors from physical sector 00:02:00 to 00:02:15

- **Use**

Boot area

Embeds a control code that limits access to the CD

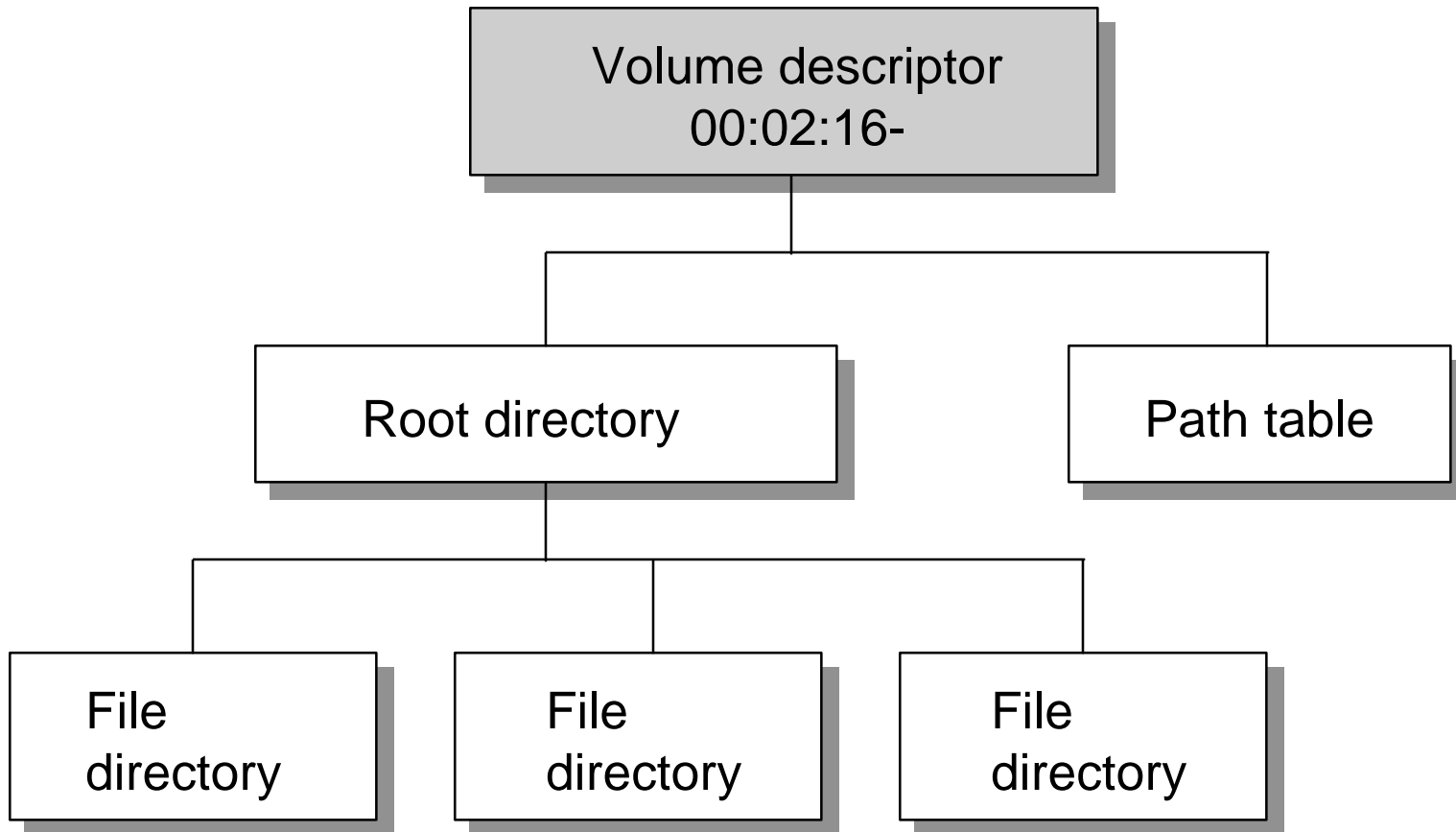
Stores data used by the interface necessary for this OS

Others



# Volume descriptor

---



## Volume descriptor (cont)

---

System Identifier	<b>PLAYSTATION</b>
Volume Identifier	<b>SLPS_*****</b>
Volume Set Identifier	(Example) <b>PSXGAME</b>
Volume Set Size	
Volume Set Seq	
Publisher Identifier	(Example) <b>SCE</b>
Data Preparer Identifier	(Example) <b>SCE</b>
Application Identifier	<b>PLAYSTATION</b>
Copyright File Identifier	
Abstract File Identifier	
Bibliographic File Identifier	
Creation Time	
Modification Time	
Expiry Time	
Effective Time	



## Path table

---

- Has all addresses of subdirectories in the hierarchy
- Improves performance of file access to the CD-ROM
- Contains one additional index of a separate hierarchical directory
- Useful for dedicated media which is read like a CD-ROM



# Filenames

---

- Filenames  
(Name) . (Extension) ; 1  
8 char 3 char
- Directory names  
(Name) [no extension]  
8 char

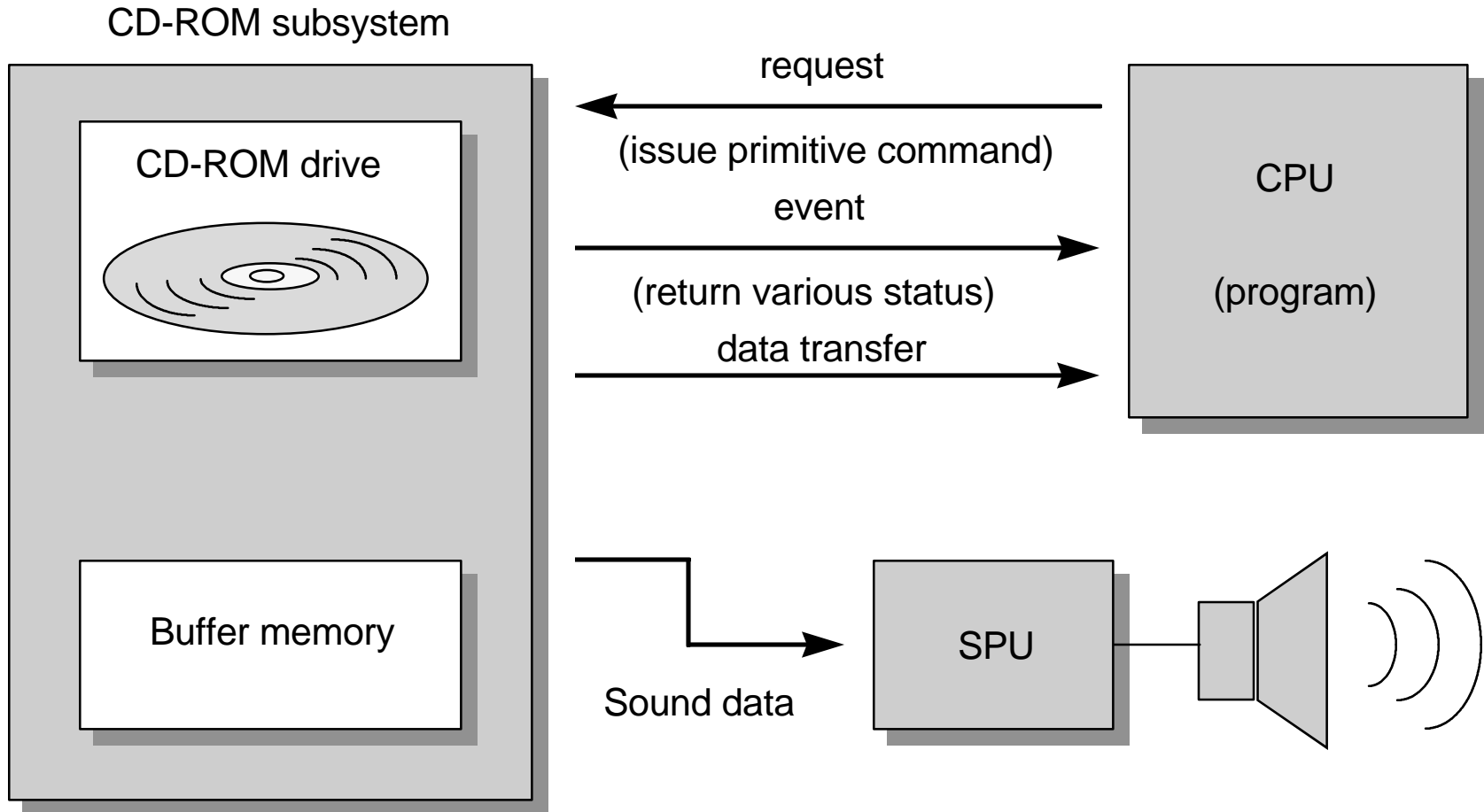


## Comparison of DOS and ISO-9660

	ISO-9660	DOS
Limit on usable characters in filenames	0-9, A-Z	0-9, A-Z _ ^ \$ ~ ! # % & - { } ( ) @ ' "
Limit of depth of hierarchy	Max. 8	Unlimited
Limit of subdirectory name	No extension	Extension



# CD-ROM playback system



## Data read

---

- Read data goes into the sector buffer of the internal subsystem
- From the sector buffer it is transferred one sector at a time to the host
- 300KByte (double speed)  
150KByte (standard speed)
- Normal Read / streaming



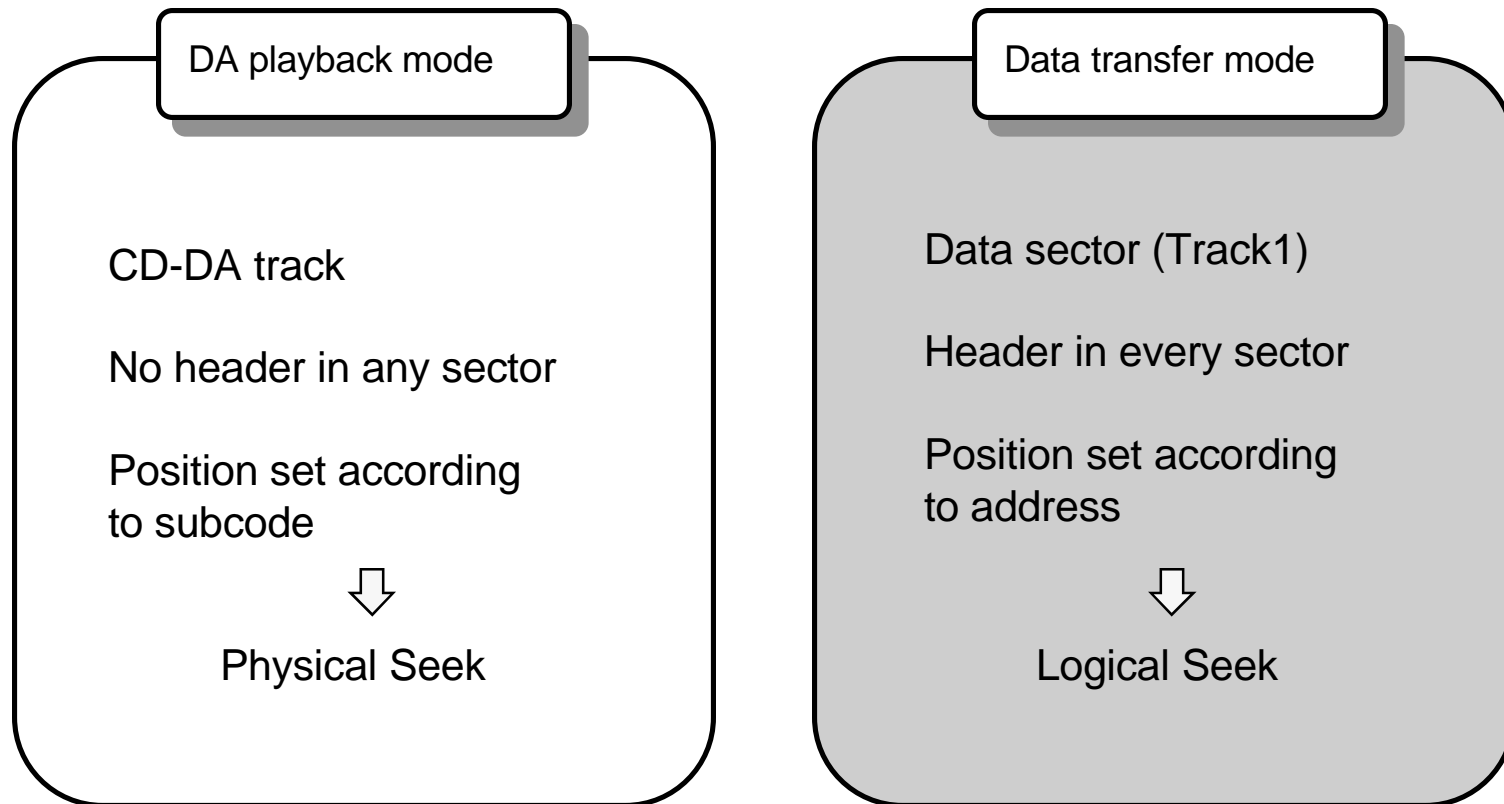
# Primitive commands

---

- Initialize
- CD Player operation (PLAY, STOP, PAUSE, FORWARD, etc...)
- Seek
- Sector Read
- Others (Status Read, etc...)



# Running mode



---

# LibCD Overview



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# LibCD

---

- LibCD is a library of low level sub-CPU functions which pertain to the CD-ROM
- Includes high level functions like file search and multisector read
- Includes the streaming library



# Using LibCD

---

```
main{  
    ResetCallback();  
    CdInit();  
    :  
    :  
    :
```

Initial program initialization



# SUB-CPU command interface

## TYPE A

**CPU**

Command

ACK or ERROR

**Sub-CPU**

Receive Command



## TYPE B

**CPU**

Command

ACK or ERROR

COMPLETE or DISK ERROR

**Sub-CPU**

Receive Command

Command Complete



## Low level functions (1)

---

- CdControlB                      Block until COMPLETE
- CdControl                        Block until ACK
- CdControlF                      Non-blocking

Parameter 1	Command code	Macro declaration
Parameter 2	Parameter	char[4]
Parameter 3	Result	char[8]
Return value	0:Error 1:ACK	



## Low level functions (2)

---

int CdSync(int mode, u\_char \*result)

int mode 0:block

mode 1:non block

Determine state of Sub-CPU

Return value CdIComplete

Command end

CdIDiskError

Error detected

CdIINTR

Command executing



# Reading data

---

- Set location
- Start read
- Wait for completion and detect errors



# Set location

---

(Example) 20 minutes, 2 seconds, sector 60

```
pos.minute    =    0x20;  
pos.second    =    0x02;  
pos.sector    =    0x60;
```

```
while(CdControl(CdlSetloc, &pos, 0) == 0);
```



# Start reading

---

(Example) Read sector 100 using multi-speed

```
while(CdRead(100, buff, CdIModeSpeed) == 0);
```

- CdRead returns immediately after the command is issued
- CdRead is a high level function



## Waiting for completion and detecting errors

---

```
int CdReadSync(int mode, u_char *result);  
int mode 0:block 1:non block
```

- Return value indicates number of remaining unread sectors
- Error is indicated when -1 is returned on a read
- Monitor as non block [non-blocking] when reading in the background



# Error processing

---

- Retry when CdReadSync return value is -1
- Retry after executing CdSetLoc



## Obtaining the location from the filename

---

```
CdIFILE *CdSearchFile(CdIFILE *fp, char *name);
```

- Example name is "\\sce\\sample.dat;1"
- Location is in fp->pos
- Directory no. 40, File no. 30 inside the directory



# Increasing read speed

---

- Reduce number of files read
- Access absolute sector
- Use background reading effectively
- Do not split the program



---

# **Description of DA/XA/Streaming data**

## **Sample Demonstration**



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# CD-DA Playback



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# CD-DA

---

- Abbreviation for Compact Disc Digital Audio
- Same format as a music CD
- Plays back at standard speed
- Information located from the data track and beyond



# CD-DA playback method

---

- Set volume
- Set mode
- Set playback point and start playback
- Process errors
- Detect termination



# Setting volume

---

- Volume is controlled through the SPU library
- Set serial attribute and serial volume
- Normally, set MAX value to 7f



# Setting mode

---

- Set mode with CdISetmode command in the sub-CPU
- CD-DA Mode (CdIModeDA)
- Report Mode (CdIModeRept)  
Report status of the sub-CPU 10X/second



# Setting playback point and starting playback

---

- Set with CdISetloc command in the sub-CPU
- For parameters, give minute, second, sector as members of the CdILOOC structure
- Format is BCD decimal notation  
(Example) 1 minute, 2 seconds, sector 30 -->  
(0x01, 0x02, 0x30)
- Begin playback with CdIPlay command



# Error processing

---

- Retry is attempted when command is not received
- Monitor DISK ERROR after start of recording



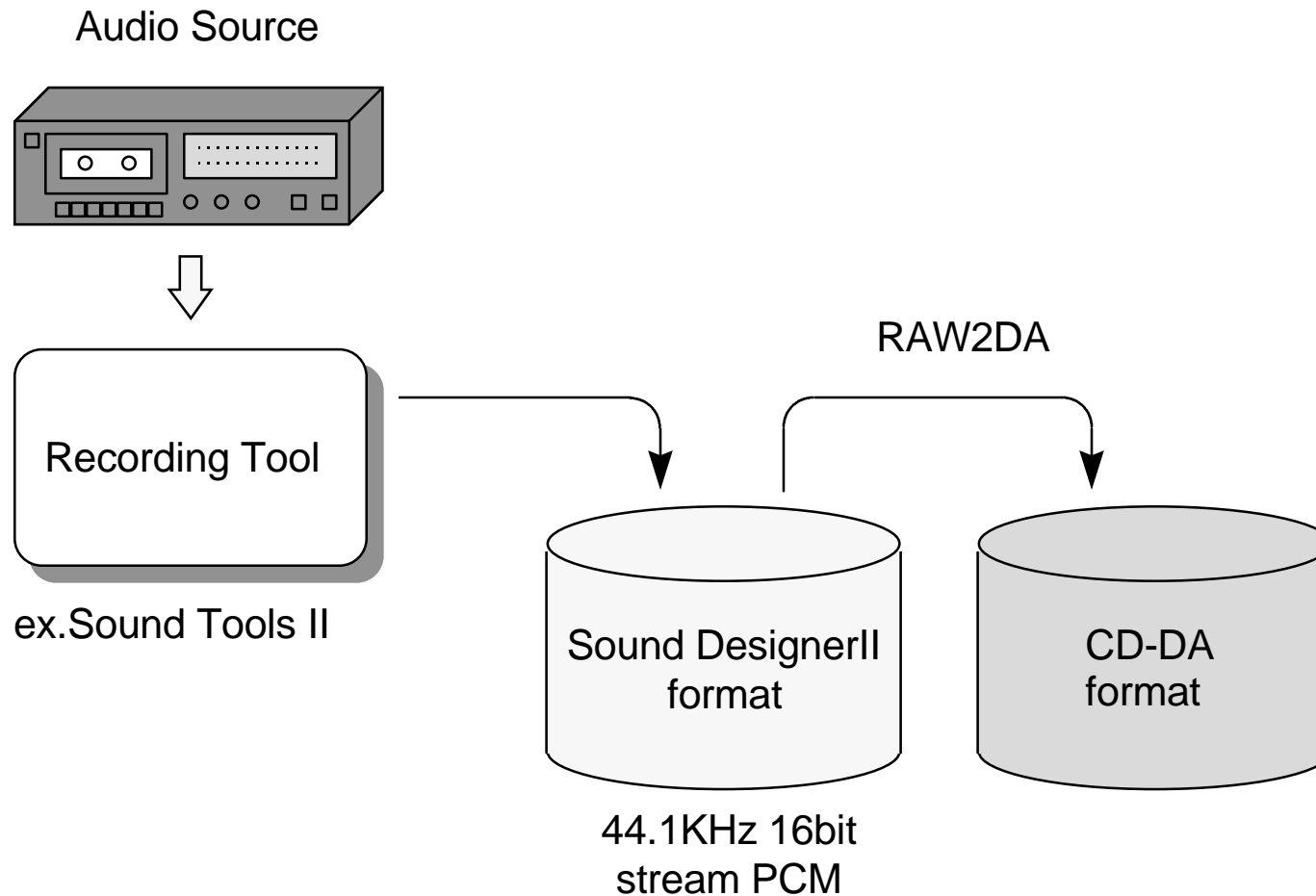
# Detecting termination

---

- Information obtained in report mode
- Comparison with a previously determined location
- Comparison is easy using logical sectors



# Creating a CD-DA file



---

# CD-XA Playback



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# CD-XA

---

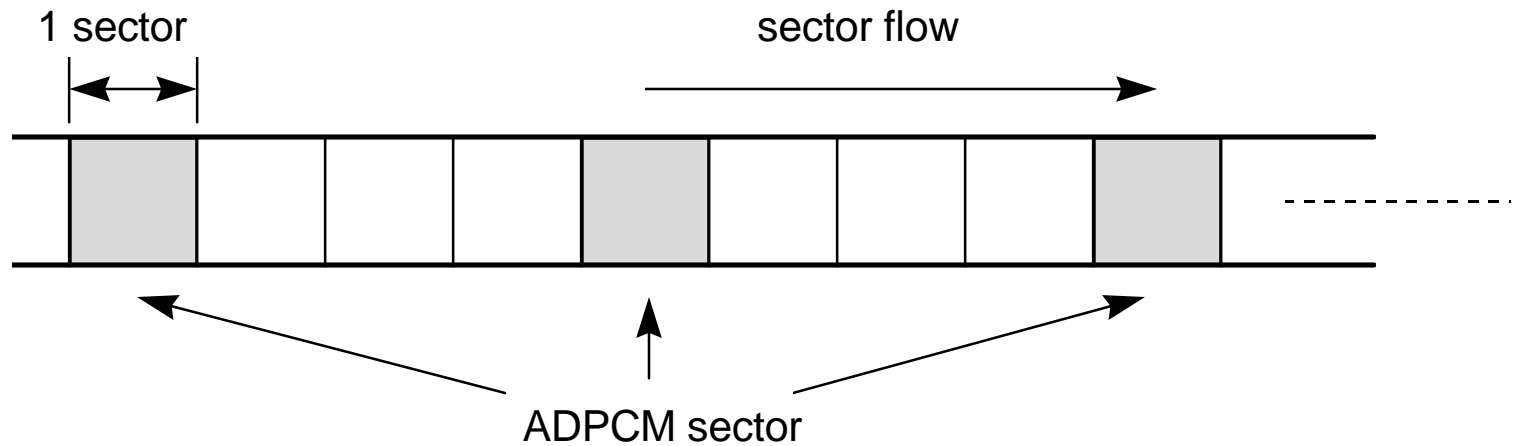
- ADPCM sound compression
- Can interleave compressed sound and data in available sections of the CD
- Two modes, B and C, depending on the rate of compression
- Another sound channel can generate sound in LR stereo



# ADPCM (XA audio)

Data quantity is 1/4 - 1/16 of CD-DA

Fs: changes 37.8 KHz / 18.9 KHz according to stereo/monaural



Adjust insertion and transfer of other sectors to come between ADPCM sectors



Interleave



# CD-XA playback method

---

- Set volume
- Select channel
- Specify playback point
- Set mode and start playback
- Process errors
- End processing



# Selecting the channel

---

- Make the "file" member of the CdIFILTER structure to "1"
- Set the desired channel in the "chan" member of the CdIFILTER structure
- Set these using the CdISetfilter command



# Setting the mode and starting playback

---

- Mode

CdIModeSpeed (during multi-speed)

CdIModeRT ADPCM playback mode

CdIModeSF Channel set mode

- Start playback and set mode

CdRead2(mode)



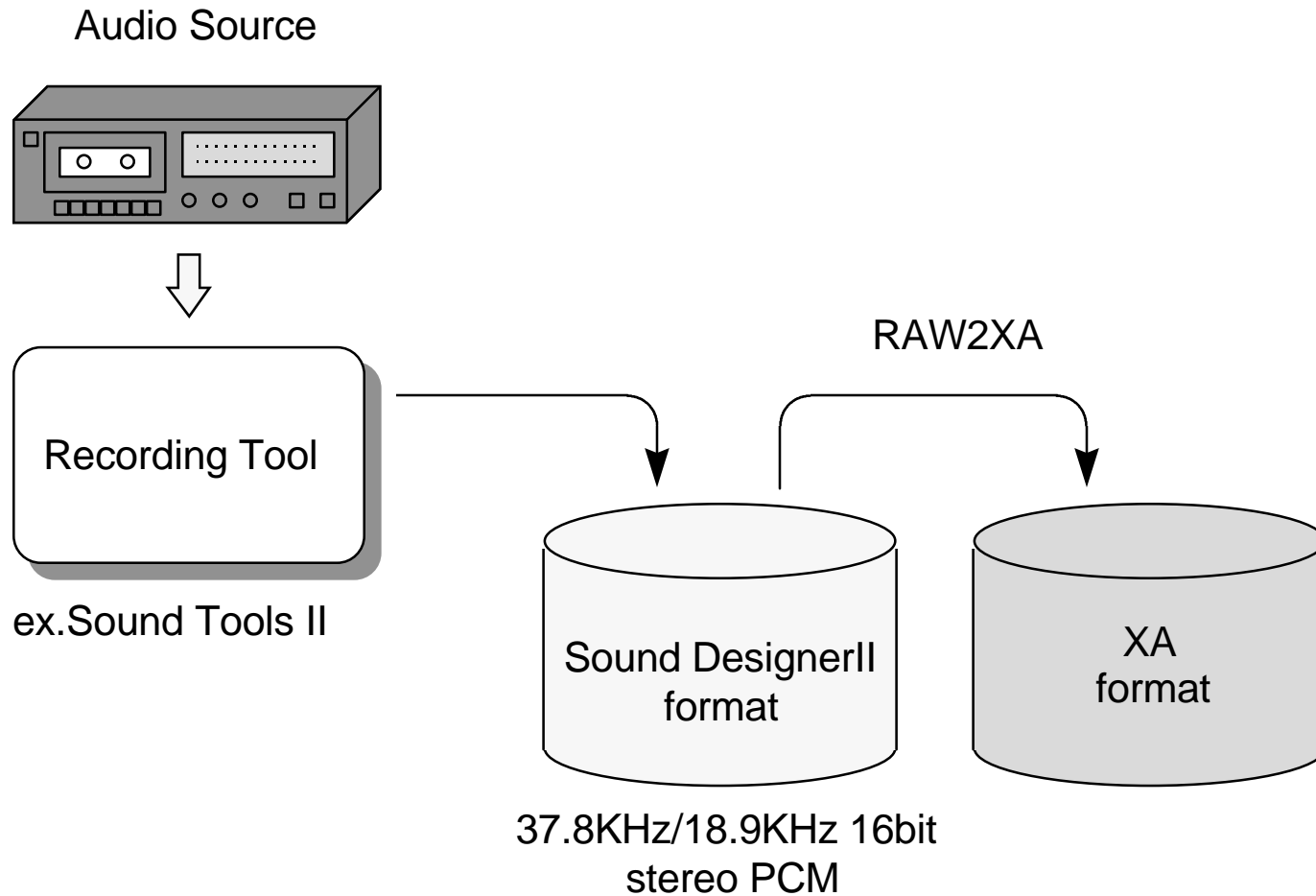
# End processing

---

- No report mode in XA
- Obtain current location with CdlGetlockL command



# Creating an ADPCM (XA) file



---

# Streaming Library

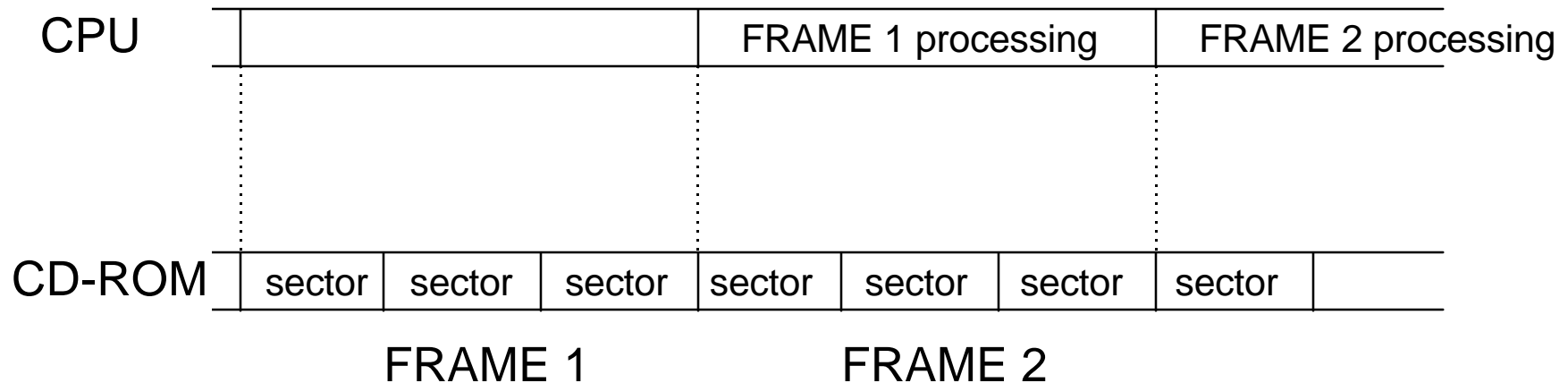


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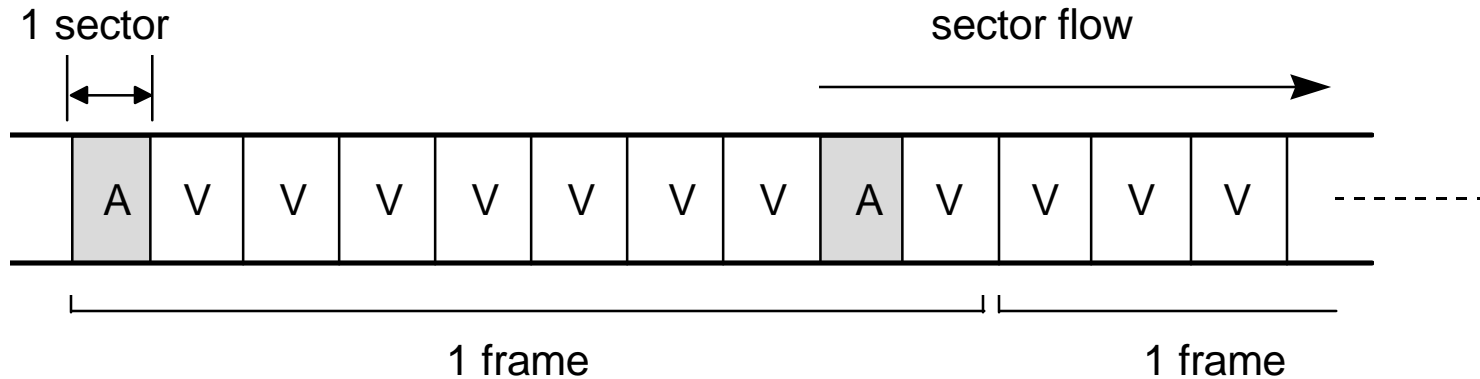
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# Streaming

- Frames of data are processed one after another without stopping the CD-ROM rotation
- A unit of processing is called a FRAME and is a collection of multiple sectors



# Structure of movie data sector



- The audio data (ADPCM) sector is interleaved at the rate of 1:8
- The number of sectors required for one frame's worth of data depends on the movie frame rate



Automatically generated by the movie converter



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# Services of the streaming library

---

- Frame processing
- Ring buffer
- Synchronous processing
- Error processing



# Frames

---

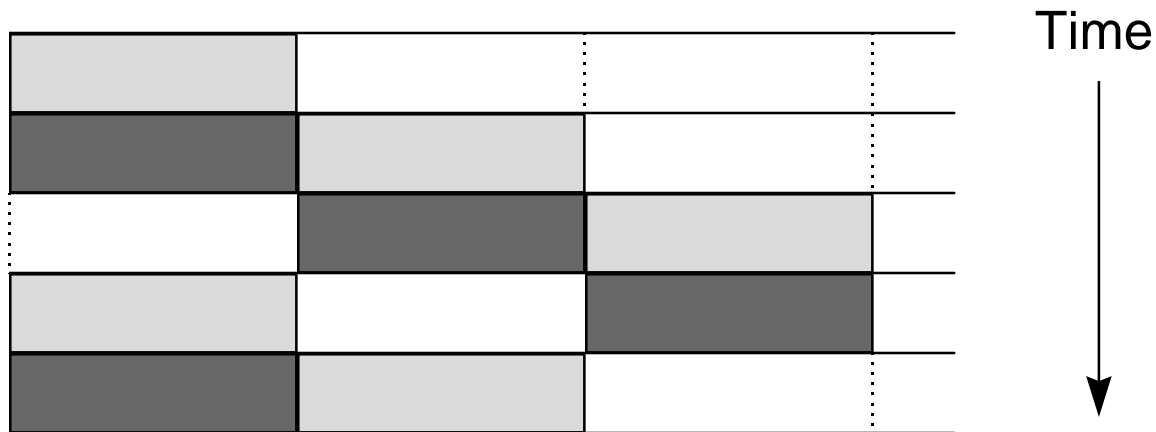
- A logically related collection of sectors  
(Example) a movie frame
- The streaming library works in units of frames
- The number of sectors which makes up a frame varies per frame
- A 32-byte sector header is included to implement a frame



# Ring buffer

- Library data is stored in a ring buffer
- The ring buffer area is maintained by the application
- The boundary of the ring buffer does not cross a frame
- The ring buffer keeps BUSY/FREE status per frame

Ring buffer transitions



Newly read frames from the CD-ROM



Frame processing in the application



# Synchronous processing

---

- Application and CD-ROM reads are asynchronous
- When processing is delayed, the ring buffer will not empty
- If the ring buffer is not empty and a new frame cannot be inserted, the library will not insert the frame (overflow)
- When processing is too fast, the ring buffer will empty (underflow)
- When a new frame cannot be extracted, the previous frame will be used in the application



# Error processing

---

- Errors are detected on a sector basis
- Frames which have sector errors are not inserted in the ring buffer



# Streaming operation

---

- Set up ring buffer (StSetRing)
- Initialize streaming library (StSetStream)
- Start CD-ROM (CdRead2)
- Acquire a frame (StGetNext, StFreeRing)
- Detect end
- Postprocess (StUnSetRing)



# Setting up the ring buffer

---

- Allocate ring buffer area on the application side
- Set buffer size to 4-5 times size of frame
- Pass the address and size of the ring buffer area to the library with `StSetRing()`



## Initialize streaming library

---

```
void StSetStream(u_long mode,  
                u_long start_frame, u_long end_frame,  
                int (*func1)(), int (*func2)());
```

mode                    1 if processing 24-bit data for animation

start\_frame            Start streaming trigger frame  
Set to 0 if no trigger

end\_frame              Callback of each frame

func2                  Normally, 0



## Streaming start

---

- After specifying location with CdSetloc command

```
int CdRead2(long mode);
```

mode	CdIModeStream	Always necessary
	CdIModeSpeed	Multi-speed play
	CdIModeRT	Simultaneously playback
		ADPCM audio





# End detection

---

- The absolute frame number is part of the streaming data
- It is monitored when end is detected
- The frame header is cast to StHEADER and compared with the FrameCount
- Actual data has 4-5 dummy frames



# Postprocessing

---

- Streaming and CdRead do not coexist
- After streaming, postprocessing occurs
- PAUSE or STOP
- StUnSetRing()



# Movies using MDEC

---

- Long movie playback is possible by combining MDEC and streaming
- Use MDECs libpress library
- A streaming frame is one movie frame



# Movie data flow

---

- Streaming one frame of data
- VLC decoder (lossless) [CPU]
- Expansion of MDEC (lossy) [MDEC]



# Compression/decompression method

---

- MDEC Initialization
- VLC Decoder DecDCTvlc()
- Input to MDEC DecDCTin()
- Output from MDEC DecDCTout()
- Switch frames



# MDEC initialization

---

- DecDCTReset (0)  
Processing is delayed since the coefficient table is transferred
- DecDCTReset (1)  
Processing is sped up as a result of Warm Reset
- Must issue DecDCTReset (0) first



# VLC decoder

---

- Decodes one frame of acquired data through the streaming library

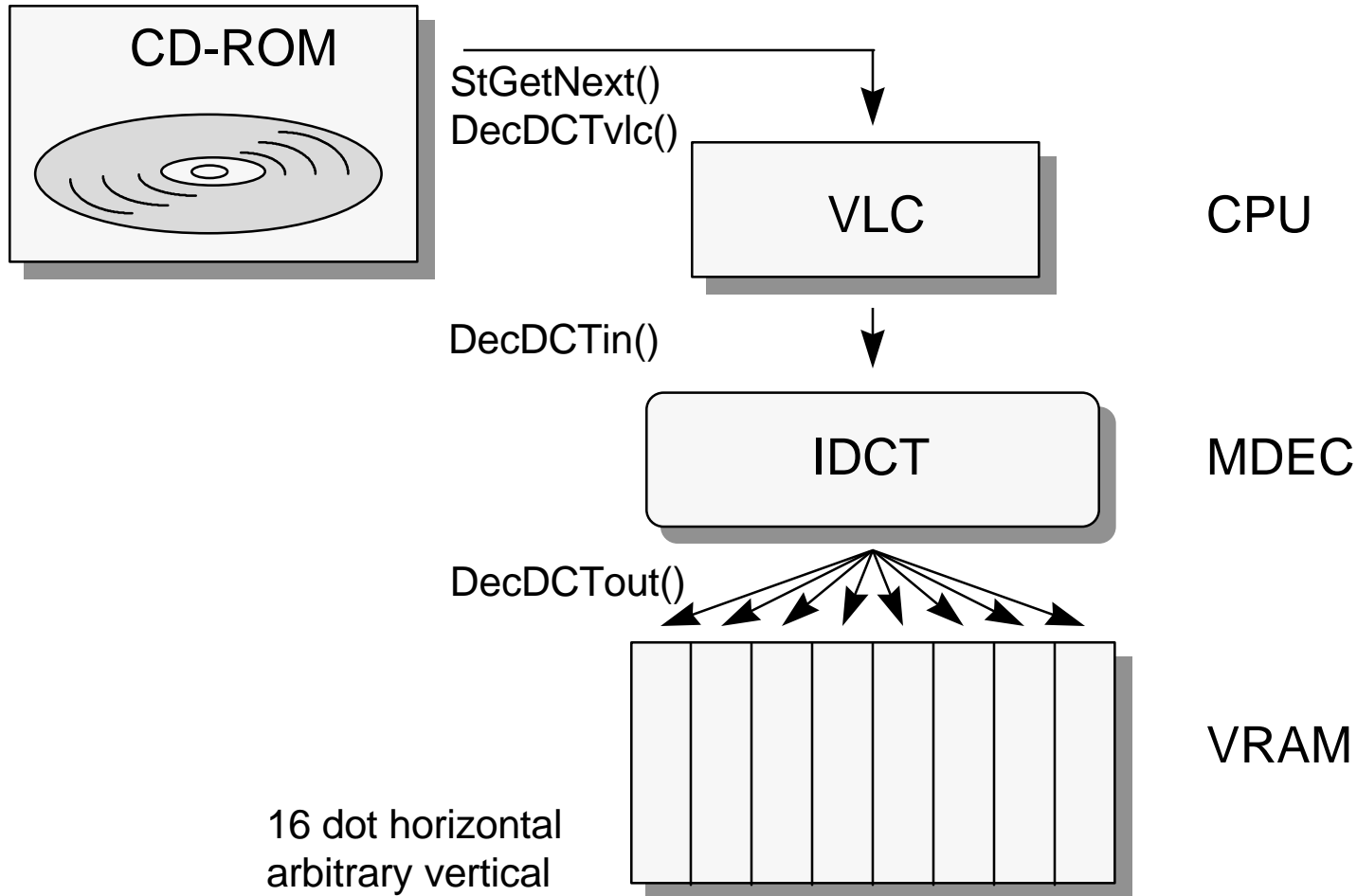
```
int DecDCTvlc(u_long *bs, u_long *buf)
```

```
    u_long *bs    input  
    u_long *buf  output
```

- Decompression takes time because it is performed in the CPU
- DecDCTvlc() does not return until decompression completes
- Data can be decompressed separately



# Image decode process using MDEC



# Table buffer

- During VLC decompression, since MDEC also aligns, VLC output is buffered in a table



# MDEC input

---

```
void DecDCTin(u_long *buf, int mode);
```

u_long *buf	start address of input region
int mode	RGB24bit/RGB16bit

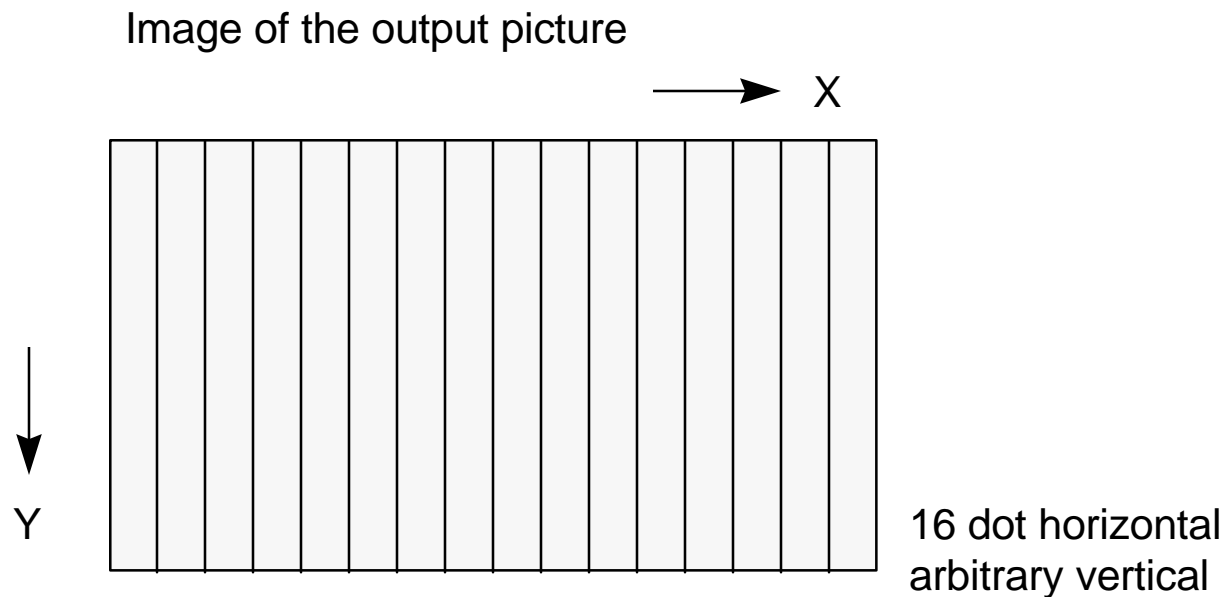
Input the input size to the input data  
Since this is only setting, this function returns immediately



# MDEC output

```
void DecDCTout(u_long *buf, int size);
```

u\_long \*buf      start address of output region  
int size        receive size



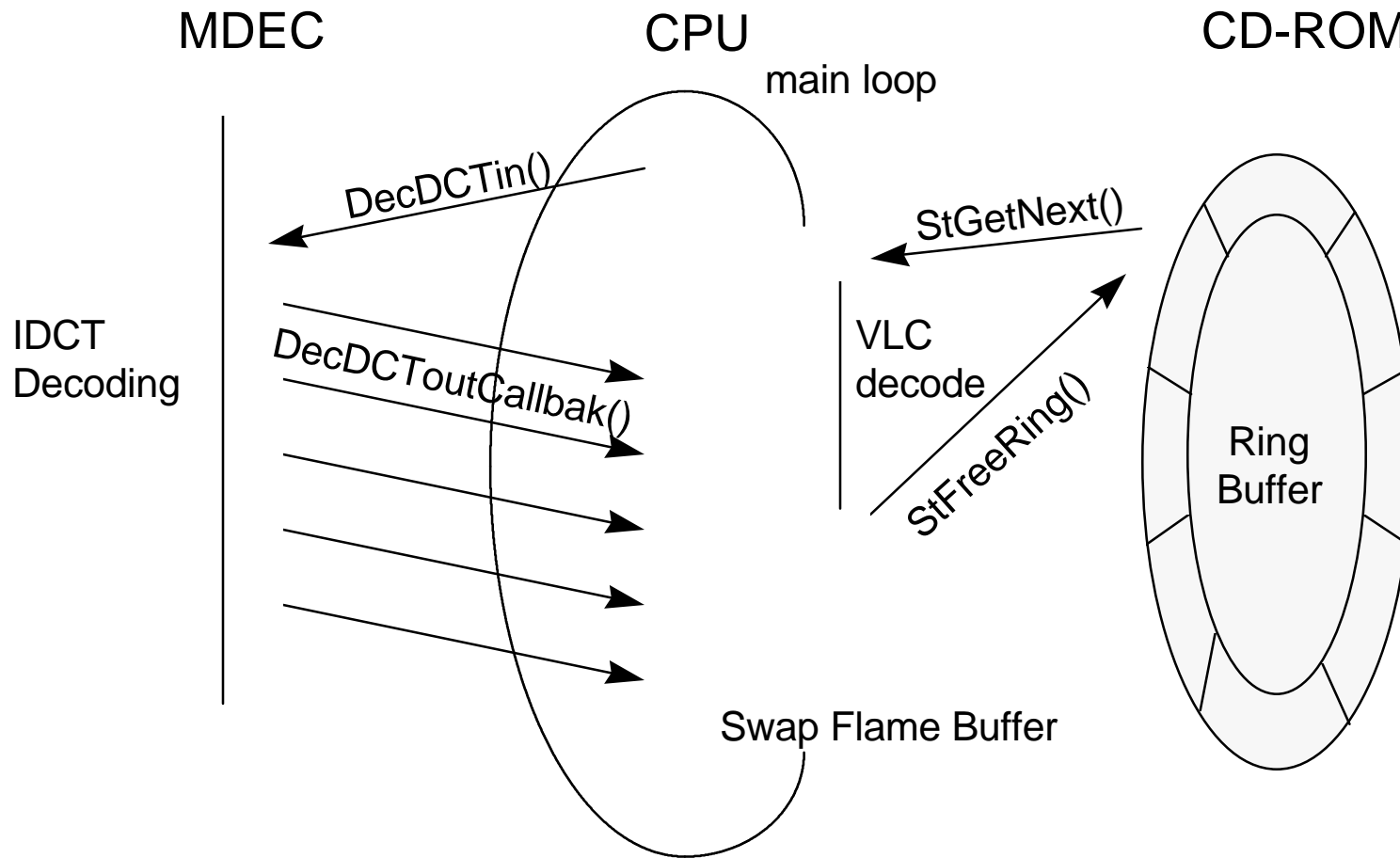
# Switching frames

---

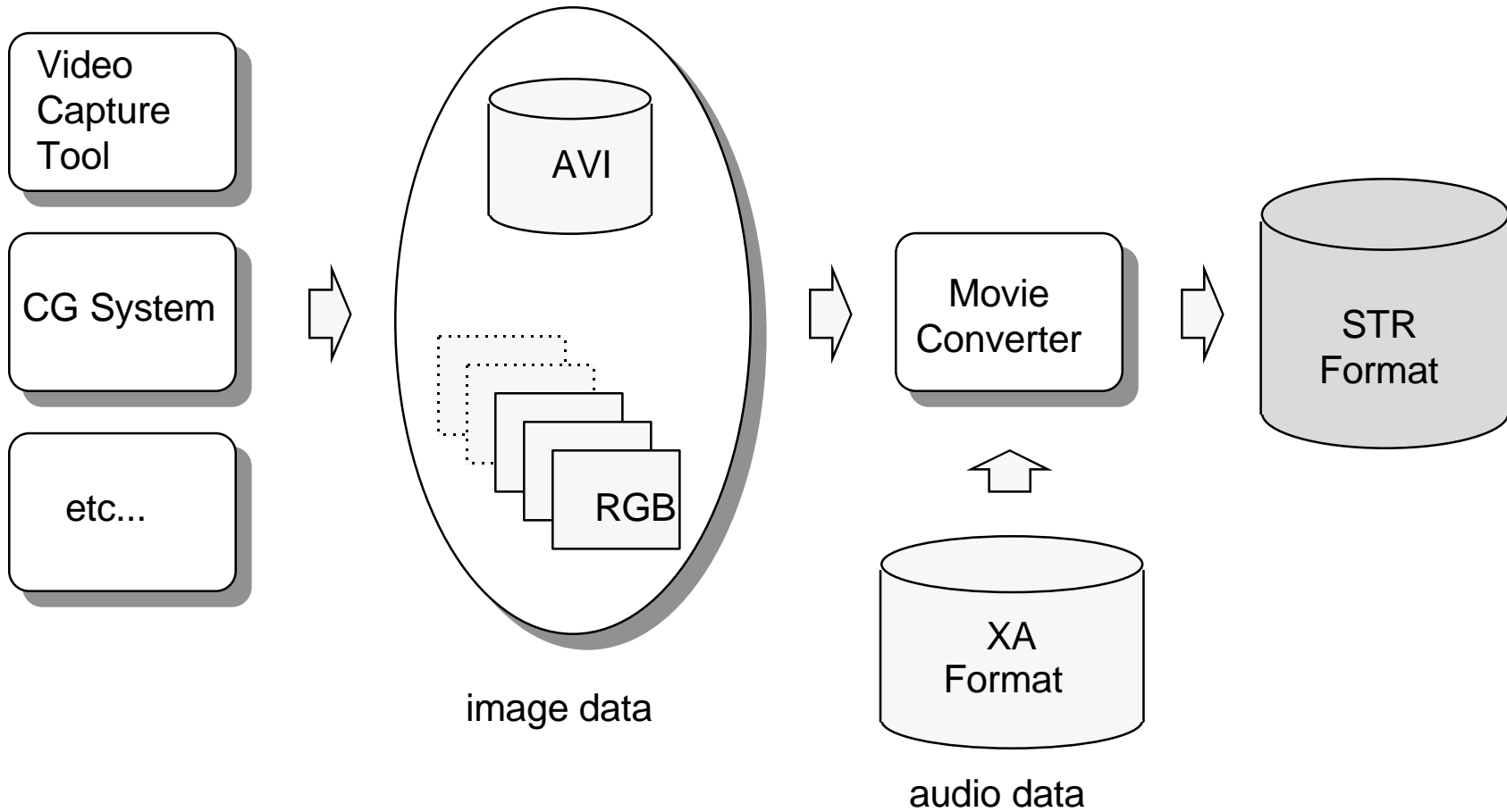
- The image packet that was output is expanded to VRAM
- The screen is switched after expanding all of the image packets on one screen to VRAM



# Animation program timing chart



# Creating movie data



---

# Execution from the CD-ROM/ CD-ROM Emulator

## Sample Demonstration



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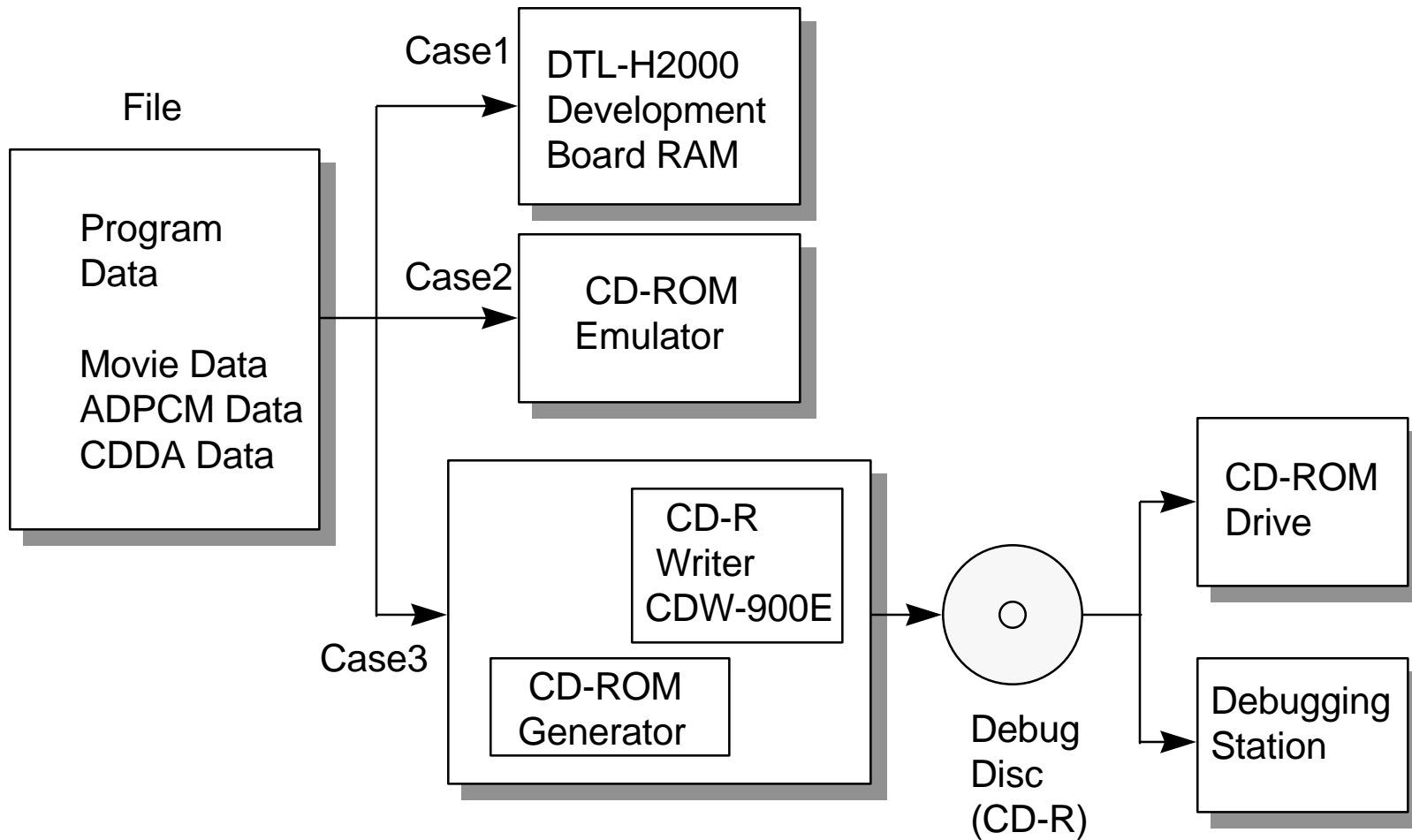
# Program operating method

---

- Execute by downloading to the DTL-H2000
- Execute from the CD-ROM Emulator
- Execute from the CD-ROM



# Development method



# CD-ROM Emulator

---

- Build the CD-ROM image to a dedicated hard disk
- Provide access timing of the nearest CD-ROM drive to the PlayStation
- Not necessary to burn the CD-R



# CD-ROM Generator

---

- CD-R Writer (CDW-900E) and creation software (for Windows)
- Necessary to create the CD-R for debug and master disk



# Sample program

---

```
/* Sample program when loading and executing the PSX.EXE on the CD-ROM/  
   CD-ROM Emulator  
   "cdexec.c"  
   [steps]   C:>ccpsx -g -Xo$801ff000 cdexec.c -ocdexec.cpe  
             C:>run patchx  
             c:>run cdexec  
*/  
void main()  
{  
    _96_remove();  
    _96_init();  
    LoadExec("cdrom:\\PSX.EXE;1", 0x801fff00, 0);1  
    /* filename  stack  stack size */  
    /* filename can be up to 20 characters */  
}
```

<sup>1</sup> Since LoadExec is a routine within ROM there is no problem if this program and the PSX.EXE effective address overlap



---

# Appendix

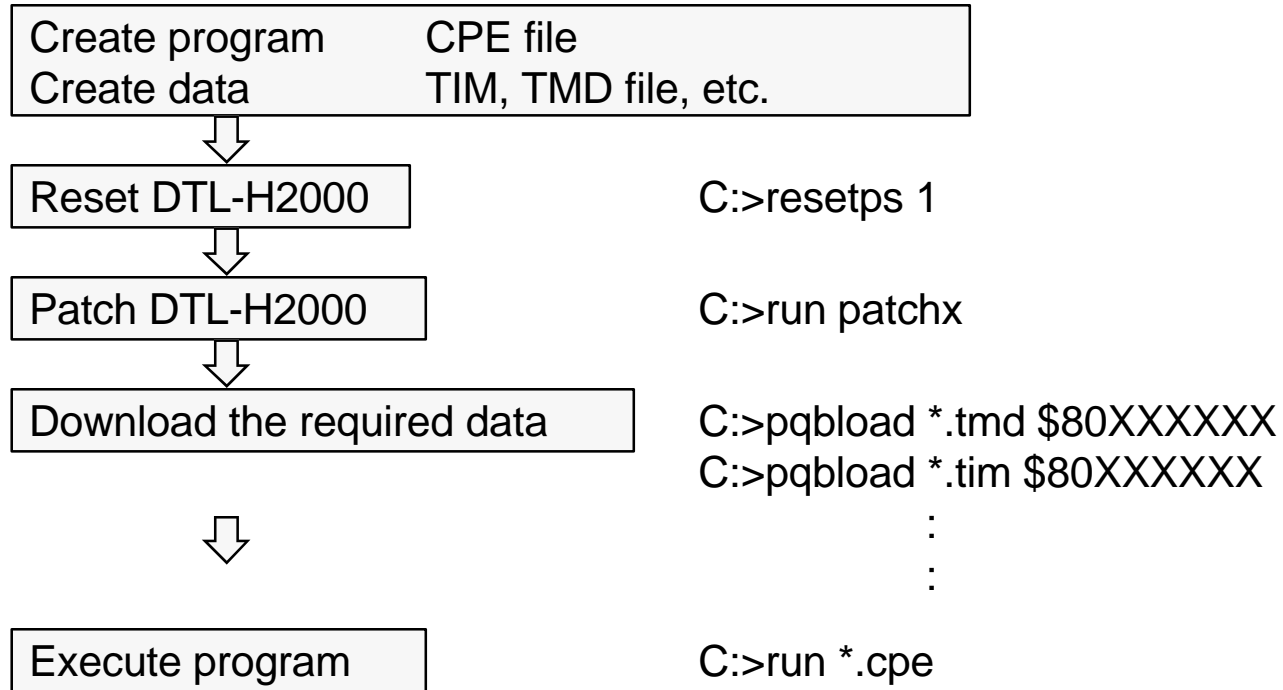


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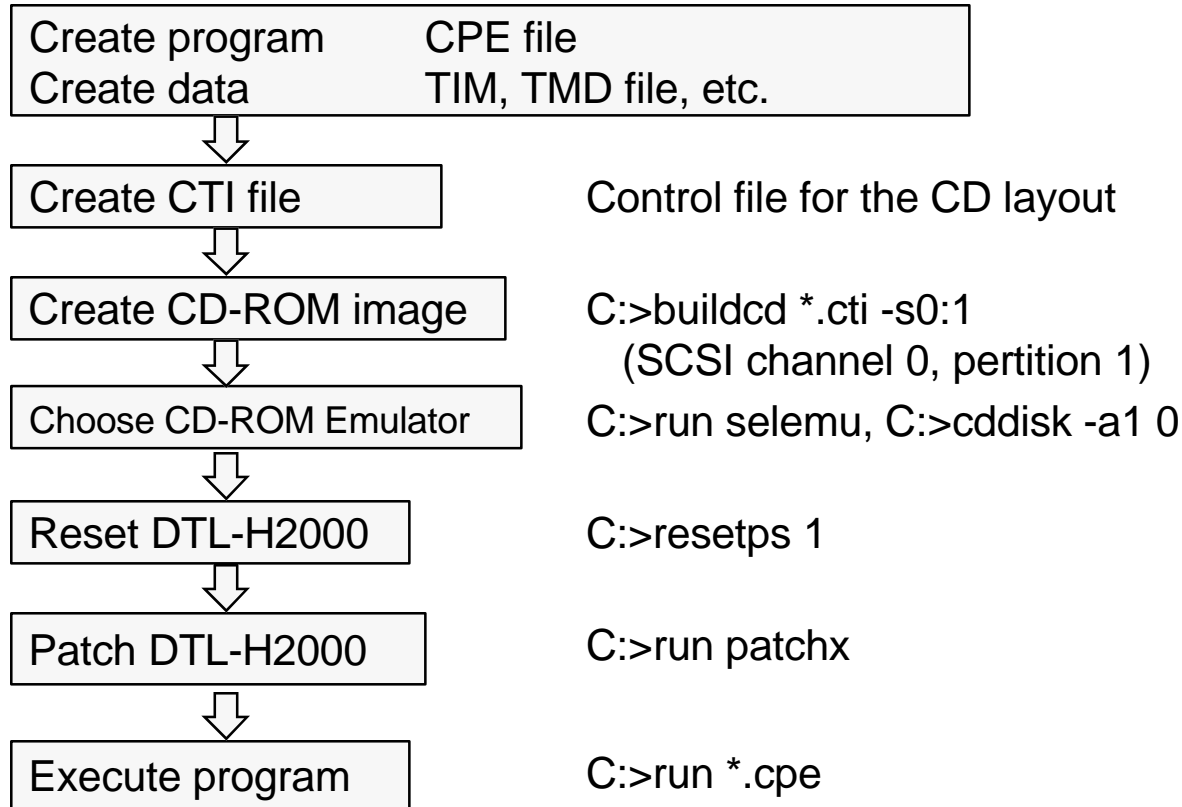
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# Downloading to the DTL-H2000



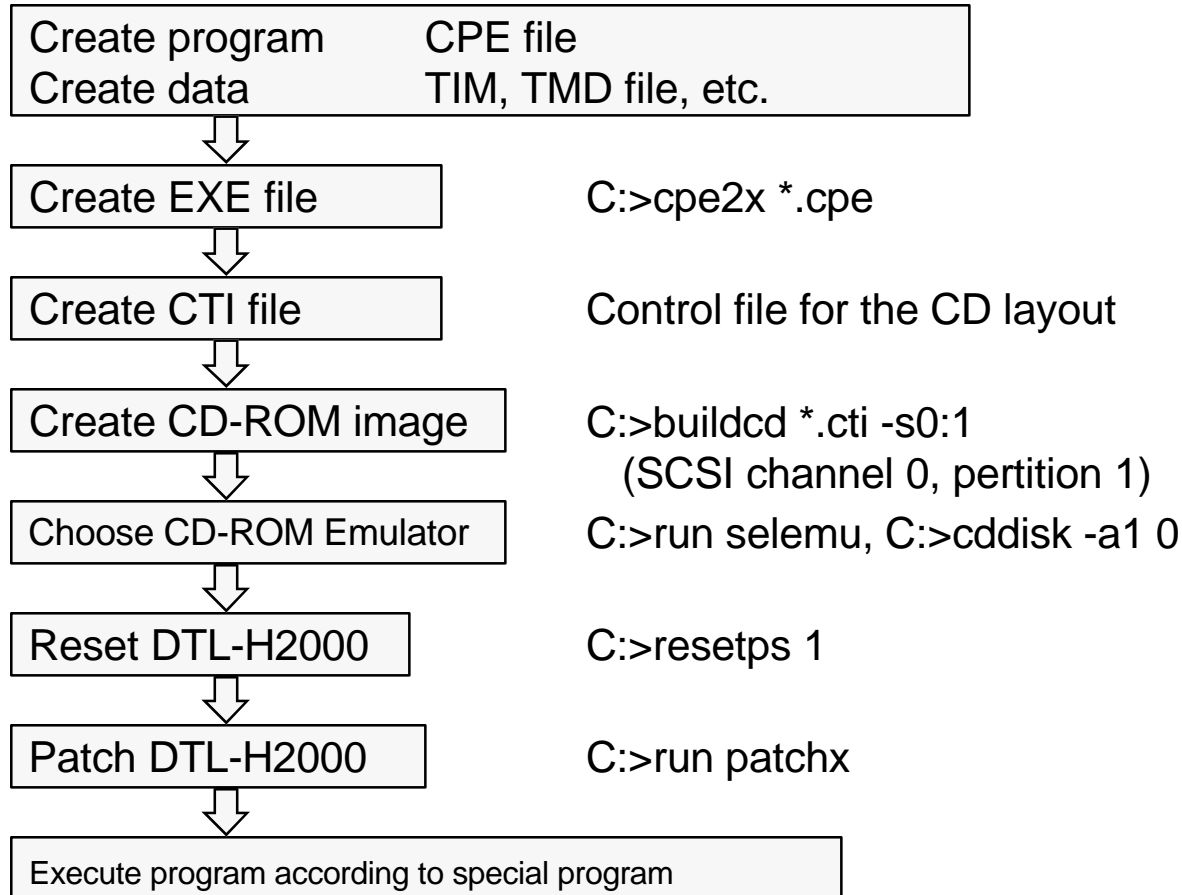
# Execution from the CD-ROM Emulator (1)

## Imaging only the data file



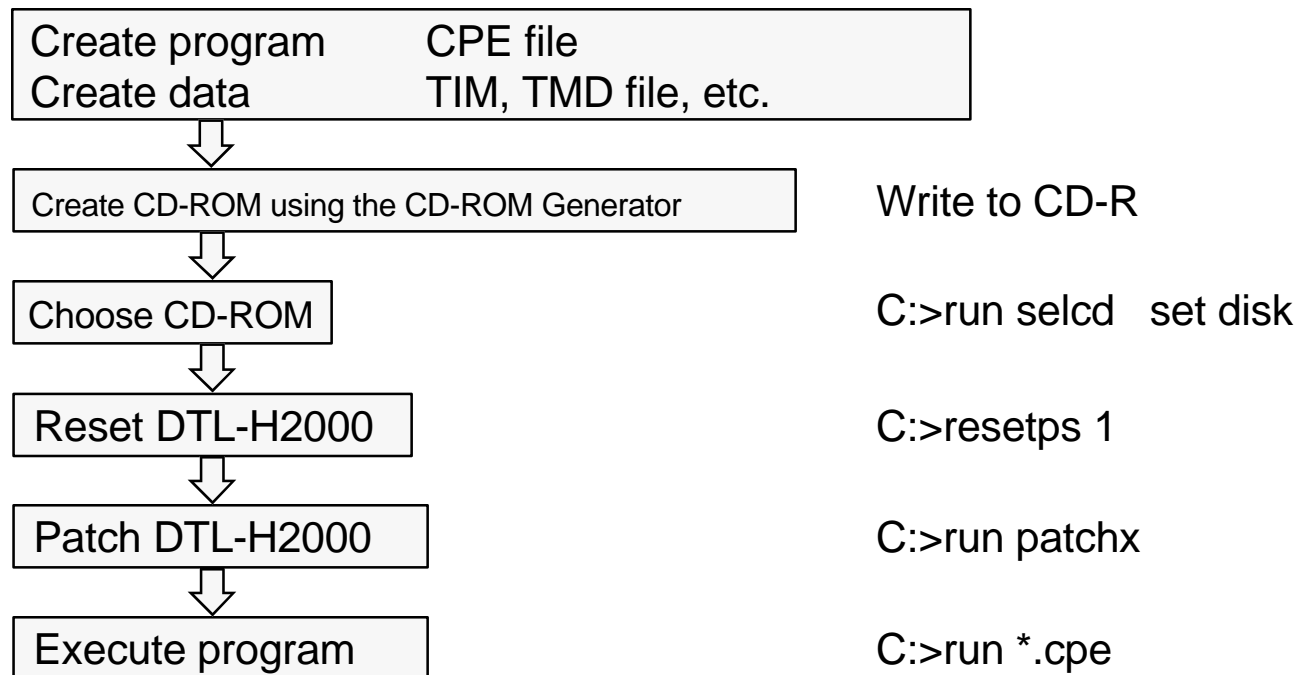
# Execution from the CD-ROM Emulator (2)

## Imaging all files



# Execution from CD-ROM (1)

Make a CD-ROM of the data file only



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## Execution from CD-ROM (2)

### Make a CD-ROM of all files

