White paper
Blu-ray Disc Format

3. File System Specifications for BD-RE, R, ROM

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1 Blu-ray Disc File System (UDF)

1.1 Introduction

   The Universal Disk Format (UDF®) specification developed by Optical Storage Technology Association (OSTA) is the predominant file system used for optical discs, eliminating any dependence on the media type, hardware platform or operating system, while allowing interchange between computer systems. (Universal Disk Format® and UDF® are registered marks of the optical Storage Technology Association.)

   UDF (Revision 2.5) has been developed considering the needs for next generation larger capacity media. To accommodate the needs of large capacity media, UDF 2.5 has added the Metadata File and Metadata Mirror File features. The Metadata File allows clustering the file system metadata (file management information, such as file entries and directories) and improves performance for accessing multiple directories. This feature enables faster start up and scanning of the disc, including better support for many utilities such as the check disc utility. The Metadata Mirror File, which is optional, is used to increase the robustness for archived data on the disc since the same metadata is recorded in the Metadata File and the Metadata Mirror File.

   Blu-ray specifies the use of UDF 2.5 as a convergent friendly format for both PC and CE environments to enable seamless interchange between PC Blu-ray drives and CE Blu-ray recorders. Specifically, the *Blu-ray Disc Format part 2 File System Specifications* defines the requirements for the use of the UDF file system on Blu-ray Rewritable discs, Blu-ray Read-Only discs and Blu-ray Recordable discs.

   On the other hand, the Blu-ray disc application (BDAV application) for recording of digital broadcasting has been developed as *System Description Blu-ray Rewritable Disc Format part 3 Audio Visual Basic Specifications*, and the requirements related with file system have been specified in *System Description Blu-ray Rewritable Disc Format part 2 File System Specifications version 1.0 (BDFS)*. Initially, the *BD-RE version 1.0 (BDFS)* was specifically developed for recording of digital broadcasting using the Blu-ray disc application (BDAV application - *System Description Blu-ray Rewritable Disc Format part 3 Audio Visual Basic Specifications*). However, to support UDF, these requirements are superseded by the *Blu-ray Rewritable Disc File System Specifications version 2.0 (UDF)* and *Blu-ray Recordable Disc File System Specifications version 1.0 (UDF)*.

   Additionally, a new application format, BDMV (*System Description Blu-ray Disc Prerecorded Format part 3 Audio Visual Basic Specifications*) for High Definition Content Distribution was developed for BD-ROM. In this case, the only file system developed for BDMV is the *System Description Blu-ray Read-Only Disc Format part 2 File System Specifications version 1.0 (UDF)* which defines the requirements for UDF 2.5.

1.2 Requirements on Blu-ray Disc for UDF Volume and File Structure

   All Blu-ray discs have the following characteristics that impact UDF; the logical sector size is 2k bytes and the ECC block size is 64k bytes. The requirements for the UDF volume and file structure are individually defined in different specifications for each media type – BD-RE, BD-R and BD-ROM.

   Blu-ray Rewritable discs are non-sequential recording media, where read-modify-write and defect management operations are performed by drive unit, eliminating the need for the Virtual Allocation Table and Sparing Table in the file system.

Blu-ray Recordable discs also include defect management, eliminating the need for the Sparing Table in the file system.   The defect management system allows for the replacement of defective clusters as well as enabling the logical overwriting of previously recorded user data.

For Blu-ray Read-Only discs, the requirements are simplified since there is no need for read-modify-write, overwriting or incremental recording of user data.

1.3 Requirements on BDAV Application Use

In the *Blu-ray Rewritable Disc File System Specifications version 2.0 (UDF)* and *Blu-ray Recordable Disc File System Specifications version 1.0 (UDF)*, the Allocation rules for the BDAV application, as previously defined in BDFS, has been modified to indicate a strong recommendation to use the Blu-ray Rewritable disc UDF file system to enable interoperability among CE Blu-ray disc recorders and personal computer systems.

1.3.1 Video/Audio Stream Recording

The allocation rule is a key feature used to manage/execute data allocation on a disc containing video/audio streams and the databases that manage those A/V streams. The file system manages the recording area on the disc in units of logical sectors and provides read and write functionality from and to the disc for applications. A/V streams and databases recorded as files on the disc by the file system have huge differences in their respective file sizes; with A/V stream files that can exceed one gigabyte in size while the database files that manage the streams range from only a few kilobytes to a few megabytes. Also, stream files are used only during actual video/audio playback when a prescribed amount of data must be read reliably from the file within a prescribed length of time, while database files are accessed more often, such as during menu display when multiple files need to be read/written rapidly and frequently.   Table 1.3.1 summarizes these concepts.

	A/V Stream file	Database file
File size	Large (MB to GB)	Small (KB to MB)
Frequency of Read/Write	little	many
Timing of Read/Write	Real-time Read/Write is necessary	Real-time Read/Write is not mandated
Action to error	The influence of an error is local. Real-time performance is more important than defect management procedure even when error occurs	Duplex writing and Error free recording by defect management are important because errors may cause a serious problems
Area Management	Area for Real-time data recording Reference player model	Area for metadata and database files Duplex writing

Table 1.3.1: Differences between stream file and database file

The recording area on the disc should be separated into an area for the metadata and database files, and a different area for real-time data recordings as shown in Fig. 1.3.1. The files recorded in the area for metadata and database files can be read with a fewer number of seeks, reducing the response time during PlayList editing and menu display, resulting in greatly improved system response.
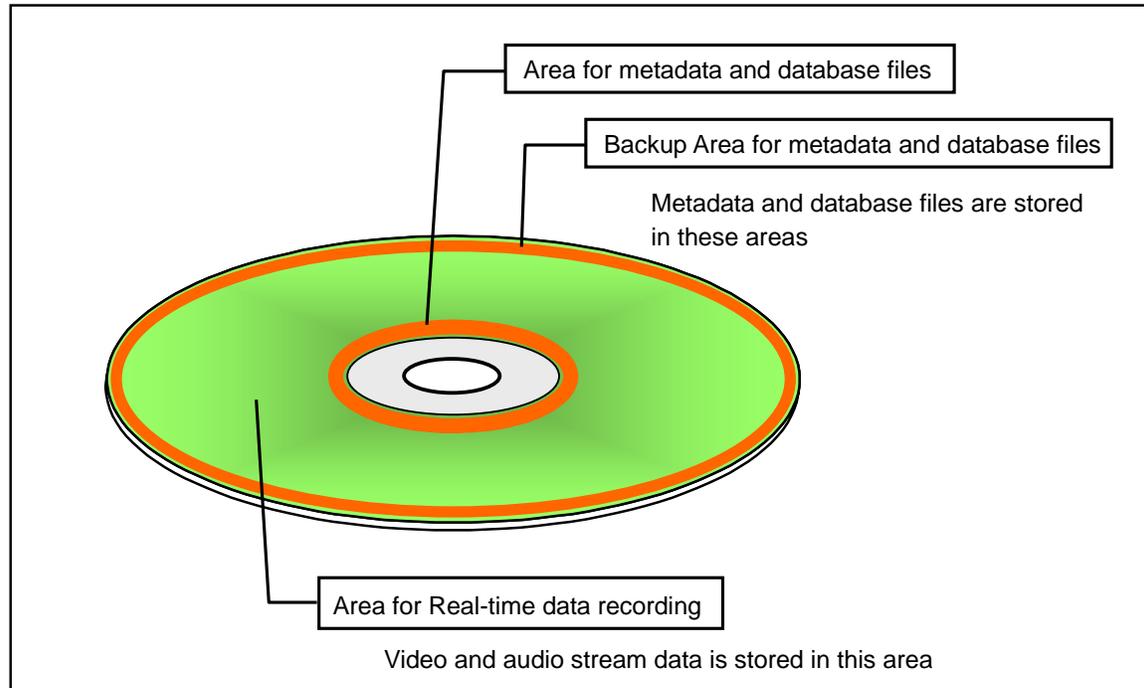
Figure 1.3.1: Recording area for different file types

An additional concern for rewritable media is its cyclability, which is the number of times any area of the disc can be overwritten and depends on the physical properties of the media. If a recording system frequently rewrites only a particular area, that particular area will wear out before the rest of the media. This can occur when a recording system continually uses and reuses areas near the inner perimeter, instead of spreading new recordings across the radius of the disc. Circular recording methods solve this problem by using a system which uses the free spaces on the disc uniformly.

1.3.2 Continuous Data Supply by Expanses

When recording, deleting or editing operations are performed repeatedly, small areas of empty space will occur across the disc. These small areas can be used to record a new Real-Time file, which results in a single Real-Time file composed of many small extents scattered across the disc. A group of these extents, each of which is recorded on contiguous logical sectors, is called an Expanse[1] (Fig. 1.3.2-1). The Expanse is conceptually a contiguous area to be read, and may include small areas in which Real-Time data is not recorded.

When a single Real-Time file is made up of several expanses, the file is read by jumping from one expanse to the next and reading the expanses in order. However, when jumping from one expanse to another, the disc rotation speed needs to be changed and the optical pickup needs to be moved to a different radius on the disc. Although data cannot be retrieved from the disc during this interval, the decoding/playback of video/audio data must continue without interruption. So to prevent any breaks

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[1] The term "Expanse" used in Blu-ray UDF is equivalent to "Extent" as used in Blu-ray BDFS.   "Extent" as defined in the UDF specification has a different meaning than as used in the Blu-ray BDFS specification.

occurring during playback, a mechanism is required to absorb the effects of the access intervals that occur between expanses.
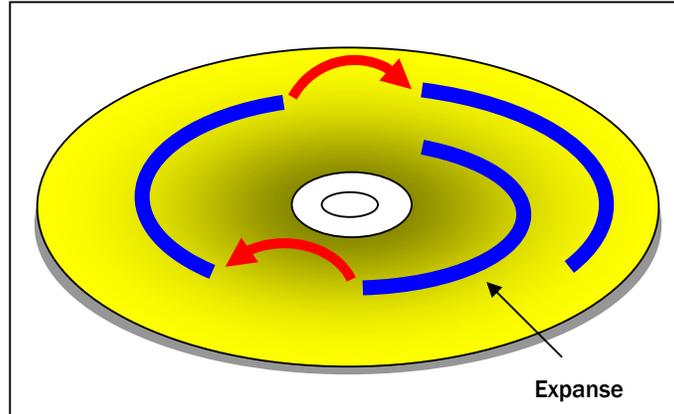

Expanse

Figure 1.3.2-1: Expanse

To prevent interruption in video/audio playback while reading data from the disc, the buffer memory must not be emptied of data before readout from the next expanse becomes possible. This requirement for continuous supply of data is necessary to insure seamless playback (Fig. 1.3.2-2, Fig. 1.3.2-3). Therefore the minimum expanse size is defined such that the buffer memory does not become empty when jumping from one expanse to another on the disc. The Blu-ray UDF file system specifications specify a larger minimum expanse size than Blu-ray BDFS to enable the design of cost effective portable players, as well as simultaneous recording and playback recorders.
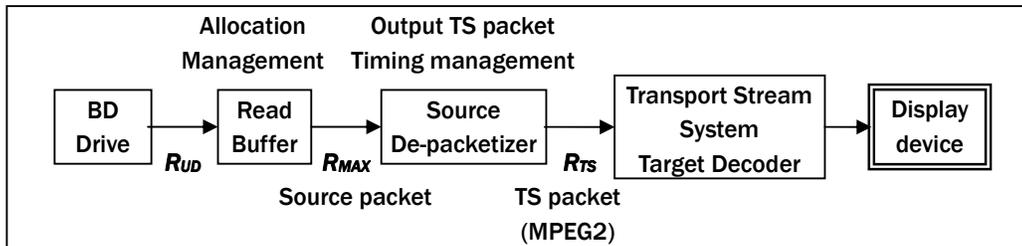

Figure 1.3.2-2:   Buffer model for reading data from disc
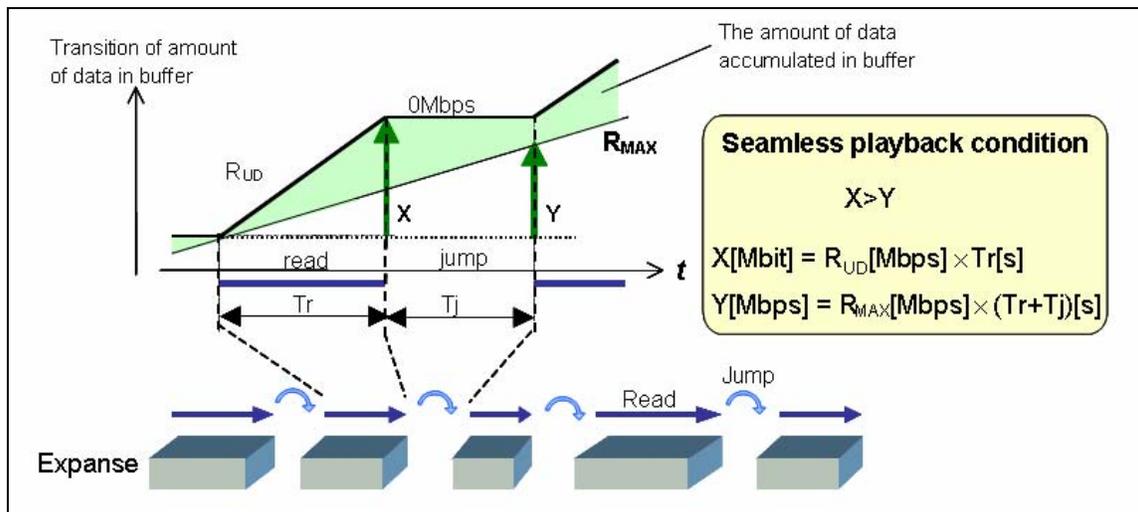

Figure 1.3.2-3:   Amount of data accumulated in the buffer during seamless playback