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FROM: N.I. MORRIS
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SUBJECT: MULTICS STANDARD TAPE RECORD LENGTH

Problems with Current MST Record Length

With the current 272 word MST record, a large percentage of tape consists of inter-record gap. This causes a large amount of the usable surface on a tape to be wasted. It also places a limitation on the effective data transfer rate from an MST in that a large percentage of time is spent in moving the tape over inter-record gaps. With the installation of 1600 bpi tape handlers, and the future possibility of having 6250 bpi handlers, these problems worsen. It would be advantageous, from the point of view of more fully utilizing the space on a tape and increasing the effective data transfer rate, to increase the size of the MST record.

Table 1 summarizes the parameters associated with the current 272 word MST record. It is obvious that with 1600 bpi tapes, almost half of the tape is wasted. Also, a significant increase in data rate does not occur. (Note that MTS-500 handlers are actually slower than MTS-400 handlers.)

Physical Considerations in Choosing a Tape Record Length

Magnetic tape records may be made arbitrarily long. However, tape is an imperfect medium, subject to physical abuse. The tape surface may deteriorate and deform. The tape edges may become crimped through mishandling. Error rates become greater at the ends of the tape. The leader experiences a great deal of wear from loading and unloading. The end of the tape undergoes some deformation from the presence of the EOT reflector on a tightly wrapped reel of tape.

It is obvious that the longer a tape record, the greater the possibility of an error in that record. It can also be seen that some errors may occur once per revolution of the tape reel. Thus, one limiting factor for tape record length is that a record should be shorter than the innermost circumference of a tape reel. (This is $5.125 \times \pi \approx 16$ inches.)¹ Studies done by Honeywell in Oklahoma City indicate that a record length of 3 to 4 inches is optimal.

1 ANSI X3B1/402

Software Considerations in Increasing MST Record Length

Increasing the size of the MST tape record will affect both the tape DCM and the tape DSM. The wired-down buffers in the DCM will have to increase in size and the buffering strategy of the DSM will require minor modification. The number of tape records which can be read or written in a single call to the tape DCM (currently 6) will no doubt have to be decreased in order to conserve wired-down core. As many records as possible, though, should be transferred in a single DCM call in order to minimize system overhead in processing interrupts, waits and notifies, etc.

One user of the tape DSM which is somewhat sensitive to tape record length is the dumper/reloader. The backup system always writes 256 word logical records on tape, padding shorter records to 256 words. It uses this fact to recover from tape read errors and resynch itself with the physical tape. If the increased record length is not a multiple of 256, the backup system might experience grave problems in reloading a tape with bad spots on it.

New MST Record Length

On the basis of the above information, a new MST record length of 1040 words is proposed. This will consist of an eight word record header, a 1024 word record body, and an eight word record trailer. The parameters associated with such an MST record are found in Table 2. MPM Reference Guide Section 5.3 has been rewritten to conform to the new record length and a revised copy is attached.

Note that, in all cases, the physical record length on tape is less than 16 inches, and for 1600 bpi tapes it is close to the optimal values discussed above. Note, too, that less than 20 percent of the tape is wasted, and that with 1600 bpi tapes, a significant increase in effective data rate results.

Tape System	Track/ Density	Tape Speed	Frames in MST Record	Frames of Data	MST Record Length	Data Length	Gap Length	Effective Date Rate	Present Use
MTS-400	7 track 800 bpi	150 ips	1632	1536	2.04"	1.92"	.75"	13763 wds/sec	68.8%
	9 track 800 bpi	150 ips	1224	1152	1.53"	1.44"	.6"	18028 wds/sec	67.6%
MTS-500	7 track 800 bpi	125 ips	1632	1536	2.04"	1.92"	.75"	11470 wds/sec	68.8%
	9 track 800 bpi	125 ips	1224	1152	1.53"	1.44"	.6"	15023 wds/sec	67.6%
	9 track 1600 bpi	125 ips	1224	1152	0.765"	0.72"	.6"	23357 wds/sec	52.6%

TABLE 1: 272 WORD MST RECORD

Tape System	Track/ Density	Tape Speed	Frames in MST Record	Frames of Data	MST Record Length	Data Length	Gap Length	Effective Data Rate	Present Use
MTS-400	7 track 800 bpi	150 ips	6240	6144	7.8"	7.68"	.75"	17964 wds/sec	89.8%
	9 track 800 bpi	150 ips	4680	4608	5.85"	5.76"	.6"	23814 wds/sec	89.3%
MTS-500	7 track 800 bpi	125 ips	6240	6144	7.8"	7.68"	.75"	14971 wds/sec	89.8%
	9 track 800 bpi	125 ips	4680	4608	5.85"	5.76"	.6"	19845 wds/sec	89.3%
	9 track 1600 bpi	125 ips	4680	4608	2.925"	2.88"	.6"	36312 wds/sec	81.7%

TABLE 2: 1040 WORD MST RECORD

Standard Data Formats and Codes

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MULTICS STANDARD MAGNETIC TAPE FORMAT

This write-up describes the standard physical format to be used on 7-track and 9-track magnetic tapes on Multics. Any magnetic tape not written in the standard format described here is not a Multics standard tape.

Standard Tape Format

The first record on the tape following the beginning of tape (BOT) mark is the tape label record. Following the tape record is an end of file (EOF) mark. Subsequent reels of a multireel sequence also have a tape label followed by EOF. (An EOF mark is the standard sequence of bits on a tape that is recognized as an EOF by the hardware.)

Following the tape label and its associated EOF are the data records. An EOF is written after every 128 data records with the objective of increasing the reliability and efficiency of reading and position within a logical tape. Records that are repeated because of transmission, parity, or other data alerts, are not included in the count of 128 records. The first record following the EOF has a physical record count of 0 mod 128.

An end of reel (EOR) sequence is written at the end of recorded data. An EOR sequence is:

EOF mark

EOR record

EOF mark

EOF mark

Standard Record Format

Each physical record consists of a 1024-word (36864-bit) data space enclosed by an 8-word header and an 8-word trailer. The total record length is then 1040 words (37440 bits). The header and trailer are each 288 bits. This physical record requires 4680 frames on 9-track tape and 6240 frames on 7-track tape. This is approximately 5.85 inches on 9-track tape at 800 bpi and 7.8 inches on 7-track tape at 800 bpi, not including interrecord gaps. (Record gaps on 9-track tapes are approximately 0.6 inches and on 7-track tapes are approximately 0.75 inches, at 800 bpi.)

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For 1600 bpi 9-track tape, the record length is approximately 2.925 inches (with an interrecord gap of approximately 0.5 inches).

Physical Record Header

The following is the format of the physical record header:

- Word 1: Constant with octal representation 670314355245.
- Words 2 and 3: Multics standard unique identifier (70 bits, left justified). Each record has a different unique identifier.
- Word 4: Bits 0-17: the number of this physical record in this physical segment, beginning with record 0.
 Bits 18-35: the number of this physical file on this physical reel, beginning with file 0.
- Word 5: Bits 0-17: the number of data bits in the data space, not including padding.
 Bits 18-35: the total number of bits in the data space.
- Word 6: Flags indicating the type of record. Bits are assigned considering the leftmost bit to be bit 0 and the rightmost bit to be bit 35. Word 6 also contains a count of the rewrite attempt, if any.

Bit Meaning if Bit is 1

- | | |
|------|---|
| 0 | This is an administrative record (one of bits 1 through 13 is 1). |
| 1 | This is a label record. |
| 2 | This is an end of reel (EOR) record. |
| 3-13 | Reserved. |
| 14 | One or more of bits 15-26 are set. |

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- 15 This record is a rewritten record.
- 16 This record contains padding.
- 17 This record was written following an end of tape (EOT) condition.
- 18 This record was written synchronously; that is control did not return to the caller until the record was written out.
- 19 The logical tape continues on another reel (defined only for an end of reel record).
- 20-26 Reserved.
- 27-35 If bits 14 and 15 are 1, this quantity indicates the number of the attempt to rewrite this record. If bit 15 is 0, this quantity must be 0.

Word 7: Contains the checksum of the header and trailer excluding word 7; i.e., excluding the checksum word. (See the MPM Reference Guide section, Standard Checksum, for a description of standard checksum computation.)

Word 8: Constant with octal representation 512556146073.

Physical Record Trailer

The following is the format of the trailer:

Word 1: Constant with octal representation 107463422532.

Words 2 and 3: Standard Multics unique identification (duplicate of header).

Word 4: Total cumulative number of data bits for this logical tape (not including padding and administrative records).

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- Word 5: Padding bit pattern (described below).
- Word 6: Bits 0-11: reel sequence number (multireel number), beginning with reel 0.
 Bits 12-35: physical file number, beginning with physical segment 0 of reel 0.
- Word 7: The number of the physical record for this logical tape, beginning with record 0.
- Word 8: Constant with octal representation 265221631704.

Note: The octal constants listed above were chosen to form elements of a single error correcting code whether read as 8-bit tape characters (9-track tape) or as 6-bit tape characters (7-track tape).

Administrative Records

The standard tape format includes two types of administrative records: 1) a tape label record; or 2) an EOR record.

The administrative records are of standard length: 8-word header, 1024-word data area, and 8-word trailer.

The tape label record is written in the standard record format. The data space of the tape label record contains:

- Words 1-8: 32-character ASCII installation code. This identifies the installation that labelled the tape.
- Words 9-16: 32-character ASCII reel identification. This is the reel identification by which the operator stores and retrieves the tape.

The remaining words are a padding pattern.

The end of reel record contains only padding bits in its data space. The standard record header of the EOR record contains the information that identifies it as an EOR record (word 6, bits 0 and 2 are 1).

Density and Parity

Both 9-track and 7-track standard tapes are recorded in binary mode with odd ones having lateral parity. Standard densities are 800 frames per inch (bpi) (recorded in NRZI mode) and 1600 bpi (recorded in PE mode).

Data Padding

The padding bit pattern is used to fill administrative records and the last data record of a reel sequence.

Write Error Recovery

Multics standard tape error recovery procedures differ from the past standard technique in that no attempt is made to backspace the tape on write errors. If a data alert occurs while writing a record, the record is rewritten. If an error occurs while rewriting the record, that record is again rewritten. As many attempts as desired can be made to write the record. No backspace record is issued.

The above write error recovery procedure is to be applied to both administrative records and data records.

Compatibility Consideration

Software shall be capable of reading Multics Standard tapes that are written with records with less than 1024 words in their data space. In particular, a previous Multics standard tape format specified a 256-word (9216-bit) data tape space in a tape record.