appendix **B**

Parameters of Disks

The most important disk parameter is the time required to locate an arbitrary disk block, given its block address, and then to transfer the block between the disk and a main memory buffer. This is the random access time for accessing a disk block. There are three time components to consider as follows:

1. **Seek time (*s*).** This is the time needed to mechanically position the read/write head on the correct track for movable-head disks. (For fixed-head disks, it is the time needed to electronically switch to the appropriate read/write head.) For movable-head disks, this time varies, depending on the distance between the current track under the read/write head and the track specified in the block address. Usually, the disk manufacturer provides an average seek time in milliseconds. The typical range of average seek time is 10 to 60 msec. This is the main *culprit* for the delay involved in transferring blocks between disk and memory.
2. **Rotational delay (*rd*).** Once the read/write head is at the correct track, the user must wait for the beginning of the required block to rotate into position under the read/write head. On average, this takes about the time for half a revolution of the disk, but it actually ranges from immediate access (if the start of the required block is in position under the read/write head right after the seek) to a full disk revolution (if the start of the required block just passed the read/write head after the seek). If the speed of disk rotation is p revolutions per minute (rpm), then the average rotational delay rd is given by

   $rd = (1/2)*(1/p)$ min $= (60*1000)/(2*p)$ msec $= 30000/p$ msec

A typical value for p is 10,000 rpm, which gives a rotational delay of $rd = 3$ msec. For fixed-head disks, where the seek time is negligible, this component causes the greatest delay in transferring a disk block.

3. **Block transfer time (*btt*).** Once the read/write head is at the beginning of the required block, some time is needed to transfer the data in the block. This block transfer time depends on the block size, track size, and rotational speed. If the **transfer rate** for the disk is tr bytes/msec and the block size is B bytes, then

   $btt = B/tr$ msec

   If we have a track size of 50 Kbytes and p is 3600 rpm, then the transfer rate in bytes/msec is

   $tr = (50*1000)/(60*1000/3600) = 3000$ bytes/msec

   In this case, $btt = B/3000$ msec, where B is the block size in bytes.

The average time (s) needed to find and transfer a block, given its block address, is estimated by

$(s + rd + btt)$ msec.

This holds for either reading or writing a block. The principal method of reducing this time is to transfer several blocks that are stored on one or more tracks of the same cylinder; then the seek time is required for the first block only. To transfer consecutively k *noncontiguous* blocks that are on the same cylinder, we need approximately

$s + (k * (rd + btt))$ msec

In this case, we need two or more buffers in main storage because we are continuously reading or writing the k blocks, as we discussed in Chapter 13. The transfer time per block is reduced even further when *consecutive blocks* on the same track or cylinder are transferred. This eliminates the rotational delay for all but the first block, so the estimate for transferring k consecutive blocks is

$s + rd + (k * btt)$ msec

A more accurate estimate for transferring consecutive blocks takes into account the interblock gap (see Section 13.2.1), which includes the information that enables the read/write head to determine which block it is about to read. Usually, the disk manufacturer provides a **bulk transfer rate (*btr*)** that takes the gap size into account when reading consecutively stored blocks. If the gap size is G bytes, then

$btr = (B/(B + G)) * tr$ bytes/msec

The bulk transfer rate is the rate of transferring *useful bytes* in the data blocks. The disk read/write head must go over all bytes on a track as the disk rotates, including the bytes in the interblock gaps, which store control information but not real data. When the bulk transfer rate is used, the time needed to transfer the useful data in one block out of several consecutive blocks is B/btr. Hence, the estimated time to read k blocks consecutively stored on the same cylinder becomes

$s + rd + (k * (B/btr))$ msec

Another parameter of disks is the **rewrite time**. This is useful in cases when we read a block from the disk into a main memory buffer, update the buffer, and then write the buffer back to the same disk block on which it was stored. In many cases, the time required to update the buffer in main memory is less than the time required for one disk revolution. If we know that the buffer is ready for rewriting, the system can keep the disk heads on the same track, and during the next disk revolution the updated buffer is rewritten back to the disk block. Hence, the rewrite time T_{rw}, is usually estimated to be the time needed for one disk revolution:

$$T_{rw} = 2 * rd \text{ msec} = 60000/p \text{ msec}$$

To summarize, the following is a list of the parameters we have discussed and the symbols we use for them:

Seek time:	s msec
Rotational delay:	rd msec
Block transfer time:	btt msec
Rewrite time:	T_{rw} msec
Transfer rate:	tr bytes/msec
Bulk transfer rate:	btr bytes/msec
Block size:	B bytes
Interblock gap size:	G bytes
Disk speed:	p rpm (revolutions per minute)