An on-demand multimedia server is equipped with a single hard disk and a large buffer space for the storage of streaming data. The buffer space can be further divided into a number of smaller buffers for the storage of the streaming data required by each admitted client. Each buffer has its turn to be read or filled. A server is said to complete a round of service when it refills all buffers. The following is the specification of the system:

- Maximum track seeking time for a stream ($t_s$) = 10.5 ms
- Maximum rotational latency ($t_r$) of disk = 5.5 ms
- Disk sector size ($s$) = 512 bytes (the minimum unit of each disk access)
- Data transfer rate ($r_d$) of disk = 8 MBytes per second
- Network consumption rate ($r_c$) = 64 kbit per second

Note that the consumption rate of the network ($r_c$) is constant across time and is the same for all clients in the system. It is given that the time to serve each client is a sum of the disk overhead time ($t_s + t_r$) and the disk read time ($r_c p_{max}/r_d$), where $p_{max}$ is the maximum duration of each round.

(a) Based on the parameters as shown above, determine the total amount of buffer memory required ($M$) when the number of admitted clients ($N$) is equal to

(i) 10;
(ii) 20;
(iii) 50;
(iv) 100; and
(v) 200.

From these results, sketch the curve of the relationship between $N$ and $M$ for that multimedia server. Comment on the curve.

(b) Assume memory is not a problem, what is the maximum number of clients that can be admitted into the system?
Solution

(a) It is known that

\[
N \left( \frac{2r_c N (t_s + t_r)}{1 - \frac{r_c N}{r_d}} + s - 1 \right) < M
\]

where \( N \) is the number of clients and \( M \) is the total buffer memory.

By substituting all parameters into that equation, it is known that:

- If \( N = 10 \), \( M > 31k \) bytes
- If \( N = 20 \), \( M > 114k \) bytes
- If \( N = 50 \), \( M > 680k \) bytes
- If \( N = 100 \), \( M > 2.8M \) bytes
- If \( N = 200 \), \( M > 12.8M \) bytes

The curve will look like the follows:

![Graph showing growth of memory requirement vs. number of clients]

It is seen that the growth of memory requirement is much faster than the growth of number of clients. An efficient admission control policy should be applied to control the number of clients in the system. It is because the memory will be used up quickly when the number of clients increases.

(b) \( N \) cannot be greater than 999 since, in this case, \( r_c \cdot N \) will be equal to \( r_d \) such that \( M \) will be equal to \( \infty \).