1. **(Co-channel interference).** Consider a regular hexagonal cell deployment, where the mobile stations (MSs) and base stations (BSs) use omni-directional antennas, as shown in Figure 1. Consider only the first tier of
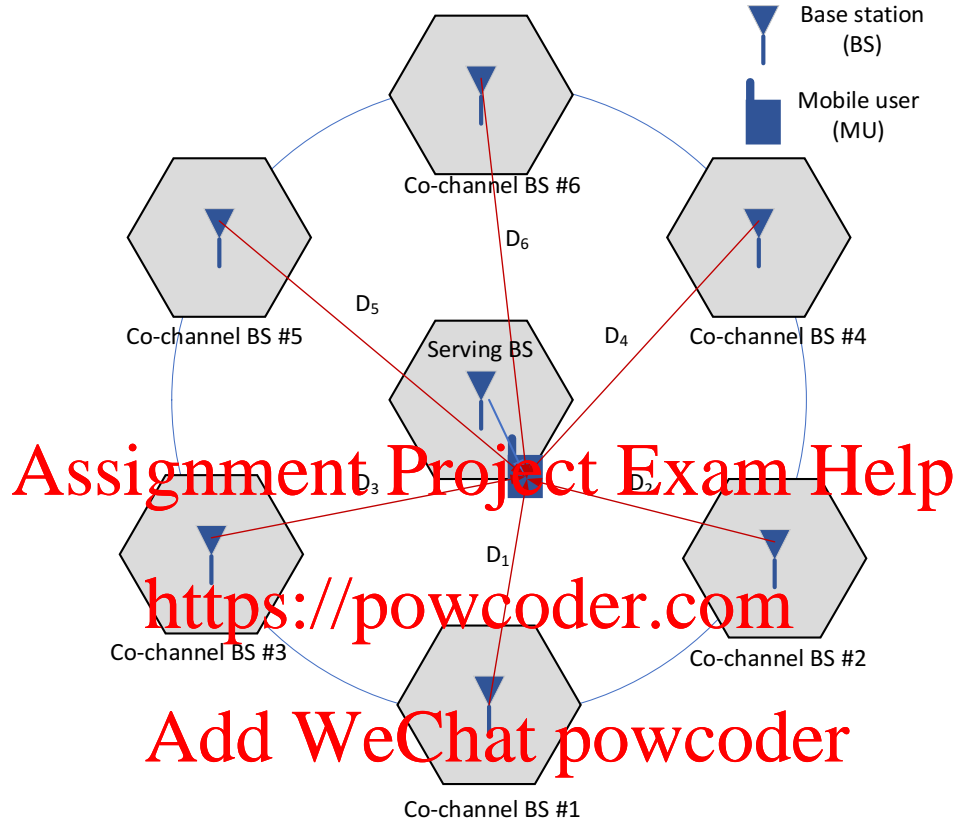

Figure 1: Worst case co-channel interference on the downlink (DL) channel.

co-channel interferes. Ignore the effects of shadowing and multipath fading. Assume that the propagation path loss is described by the simplified path-loss model (refer the class note).

(a) Determine the worst-case downlink (DL) carrier-to-interference ratio, $\frac{C}{I}$, for cluster sizes $N = 3,\ 4,\ 7$ when the path loss exponent is 3.5.
   Hint: Distances from six interfering BSs are
   $\{2R,\ \sqrt{7}R,\ \sqrt{7}R,\ \sqrt{13}R,\ \sqrt{13}R,\ 4R\}$ *when $N = 3$*
   $\{\sqrt{7}R,\ \sqrt{7}R,\ \sqrt{13}R,\ \sqrt{13}R,\ \sqrt{19}R, \sqrt{19}R\}$ *when $N = 4$*
   $\{\sqrt{13}R,\ 4R,\ \sqrt{19}R,\ 5R,\ \sqrt{28}R,\ \sqrt{31}R\}$ *when $N = 7$*
   where R is the radius of the cells.

(b) What are the minimum cluster sizes that are needed if threshold levels of the carrier-to-interference ratio at radio receivers are $5\,\mathrm{dB}$ and $10.5\,\mathrm{dB}$?