

Merge Sort has the following equation  $T(n) = 2^k \cdot T(\frac{n}{2^k}) + k \cdot cn$

$$T(\frac{n}{2^k}) = T(1) = \text{constant}$$

given  $\log_2 n = k$

$$\begin{aligned} & 2^k \cdot T(1) + k \cdot cn \\ &= 2^{\log n} \cdot T(1) + \log n \cdot cn \\ & \quad \downarrow \\ & 2^k = n \end{aligned}$$

$$\begin{aligned} &= n \cdot C + \log n \cdot C \cdot n \\ &= n + n \log n \end{aligned}$$

$$\downarrow$$

$O(n \log n)$