Base Case $T(0) = T(1) = 1$

$O(N\log N)$

Merge sort

$$\boxed{T(n) = 2T\left(\frac{n}{2}\right) + n}$$ → Recurrence Relation (RR)

Telescoping Analysis.

Step 1: Divide RR by n.

$$\frac{T(n)}{n} = \frac{2T\left(\frac{n}{2}\right)}{n} + 1$$

Step 2: Bring 2 in the RHS to denominator.

$$\frac{T(n)}{n} = \frac{T\left(\frac{n}{2}\right)}{\left(\frac{n}{2}\right)} + 1.$$

Eq is valid for $\forall n$ that is power of 2.

Step 3 Telescoping. $n = \frac{n}{2}$

$$\frac{T\left(\frac{n}{2}\right)}{\frac{n}{2}} = \frac{T\left(\frac{n}{4}\right)}{\frac{n}{4}} + 1$$

$n = \frac{n}{4}$

$$\frac{T\left(\frac{n}{4}\right)}{\frac{n}{4}} = \frac{T\left(\frac{n}{8}\right)}{\frac{n}{8}} + 1.$$

$\vdots$

$n = 2$

$$\frac{T(2)}{2} = \frac{T(1)}{1} + 1.$$

Step 4: Sum LHS = SUM RHS

$$\frac{T(n)}{n} + \cancel{\frac{T(\frac{n}{2})}{\frac{n}{2}}} + \cancel{\frac{T(\frac{n}{4})}{\frac{n}{4}}} + \cdots \cancel{\frac{T(2)}{2}} =$$

$$\cancel{\frac{T(\frac{n}{2})}{\frac{n}{2}}} + 1 + \cancel{\frac{T(\frac{n}{4})}{\frac{n}{4}}} + 1 + \cancel{\frac{T(\frac{n}{8})}{\frac{n}{8}}} + \cdots +$$

$$\cdots \cancel{\frac{T(2)}{2}} + 1 + \frac{T(1)}{1} + 1$$

$$\frac{T(n)}{n} = T(1) + \log n$$

$$\frac{T(n)}{n} = (1 + \log n)$$

$$T(n) = n(1 + \log n)$$

$$= n + n \log n$$

$$= O(n \log n)$$