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CS F364 Design & Analysis of Algorithms

## DIVIDE-AND-CONQUER

**Example: Matrix Multiplication**

**Classic Algorithm: Linear Division**

# Classic Matrix Multiplication

- Multiply matrices A and B ( each of size  $N \times N$ )

1. Multiply Row 1 of A with B



2. Multiply matrix A' (rows 2 to N of A) with B



# Classic Matrix Multiplication

- Multiply matrices A and B (each of size  $N \times N$ )

1. Multiply Row 1 of A with B

1. Multiply Row 1 of A with Column 1 of B



2. Multiply Row 1 of A with B' (columns 2 to N of B)

2. Multiply matrix A' (rows 2 to N of A) with B



# Classic Matrix Multiplication

- Multiply matrices A and B (size  $N \times N$ )
    1. Multiply Row 1 of A with B
      1. Multiply Row 1 of A with Column 1 of B
        1. Add  $A_{11} \times B_{11}$  to  $C_{11}$  (the result)
      2. Multiply Row 1' of A with Column 1' of B
    2. Multiply Row 1 of A with B' (columns 2 to N of B)
  - 2. Multiply matrix A' (rows 2 to N of A) with B
- In each case, sub-problem 2 has the same structure as the problem it was decomposed from
  - i.e. sub-problem 2 is the induction hypothesis



# Classic Matrix Multiplication

- This translates to a straightforward program with three nested loops.
  - If we assume each matrix is of size  $N \times N$
  - then the time complexity is  $O(N^3)$ .
- Can we do better?

