Construction of a house takes 5 days

Construction divided into sub tasks

foundation walls roof door windows

<table>
<thead>
<tr>
<th>Day 1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6</th>
<th>D7</th>
<th>D8</th>
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<tbody>
<tr>
<td>House 1</td>
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</table>

→ After 4 days, it appears as if a new house is constructed/completed every single day

→ Pipelined
**Speedup** = \( \frac{\text{old time}}{\text{new time}} \)

**To construct** \( n \) **houses**

- **without pipeline**: \( n \cdot 5 = 5n \) days
- **with pipeline**: \( (4-1) + n \cdot 1 = (4-1)+n \) days

\[ \text{no house} \quad \text{one house} \quad \text{(startup cost) completed every single day} \]

\[ \text{Speedup} = \frac{5n}{(4-1)+n} \]

**If** \( n \) \( \approx \) **say** \( 1 \) **million**

\[ \text{Speedup} = \frac{5M}{1M+3} \approx 5 \]

**For sufficiently large** \( n \), \( (4-1) \) \( \approx \) **negligible**

\[ \text{Speedup} = \frac{5n}{n} = 5 \]
A number of stages in the pipeline ($k$) [pipeline depth]

\[ \text{Speedup} = \frac{k \cdot n}{n} = k \]

What if I am able to further divide the sub-tasks

\[ \text{Foundation} \rightarrow \text{Walls} \rightarrow \text{Roof} \rightarrow \text{Door} \rightarrow \text{Windows} \]

\[ F_1 \rightarrow F_2 \rightarrow w_1 \rightarrow w_2 \rightarrow R_1 \rightarrow R_2 \rightarrow D_1 \rightarrow D_2 \rightarrow w_1 \rightarrow w_2 \]

If each sub-task takes 0.5 days, the speedup achieved is?

It appears as if a new house is completed every 0.5 days.

\[ \text{Speedup} = 10 \] (2x the previous design where the #tasks was 5)

Can I keep sub-dividing the tasks to achieve higher speedup?
What happens if the division is as below:

- Foundation
- Walls
- Roof
- Door
- Windows

0.75 days each

2 days

The first 4 tasks take only 0.75 days each.
Placing the windows takes 2 days.
A single house still takes 5 days to complete.

Speedup = ?

Imbalance in the pipeline