

### Original loop

```
For i = 1 to M  
  INS A  
  INS B  
  INS C  
Endfor
```

Assume loop independent dependencies between A and B, as well as between B and C: A,B,C of the same iteration must execute sequentially

### No Parallelization

Execution time:  $3M$  cycles

```
INS A1  
INS B1  
INS C1  
INS A2  
INS B2  
INS C2  
INS A3  
...
```

### Loop Pipelining

Execution time:  $M+2$  cycles

|        |        |        |            |
|--------|--------|--------|------------|
| INS A1 |        |        |            |
| INS B1 | INS A2 |        |            |
| INS C1 | INS B2 | INS A3 |            |
|        | INS C2 | INS B3 | INS A4     |
|        |        | INS C3 | INS B4 ... |
|        |        |        | INS C4 ... |

### Loop Pipelining + Unrolling (factor 2)

Execution time:  $M/2+2$  cycles

|        |        |                   |
|--------|--------|-------------------|
| INS A1 | INS A2 |                   |
| INS B1 | INS B2 | INS A3 INS A4     |
| INS C1 | INS C2 | INS B3 INS B4 ... |
|        |        | INS C3 INS C4 ... |

### Loop Pipelining + Unrolling (factor 2) + Duplicated Datapath

Execution time:  $(M/2)/2+2$  cycles

|        |        |                   |
|--------|--------|-------------------|
| INS A1 | INS A2 |                   |
| INS B1 | INS B2 | INS A3 INS A4     |
| INS C1 | INS C2 | INS B3 INS B4 ... |
|        |        | INS C3 INS C4 ... |

|                 |                 |                                 |
|-----------------|-----------------|---------------------------------|
| INS $A_{M/2+1}$ | INS $A_{M/2+2}$ |                                 |
| INS $B_{M/2+1}$ | INS $B_{M/2+2}$ | INS $A_{M/2+3}$ INS $A_{M/2+4}$ |
| INS $C_{M/2+1}$ | INS $C_{M/2+2}$ | INS $B_{M/2+3}$ INS $B_{M/2+4}$ |
|                 |                 | INS $C_{M/2+3}$ INS $C_{M/2+4}$ |