TIMING

Lecture-13

Timing in dataflow graphs

- SDF (and KPN) focus only on functionality and dependencies
- Execution of processes takes time in practice
  - Time is a function of hardware and technology used

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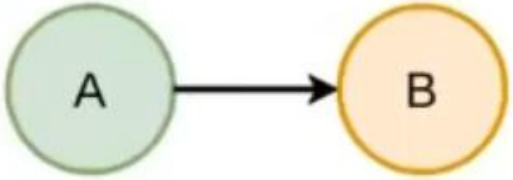
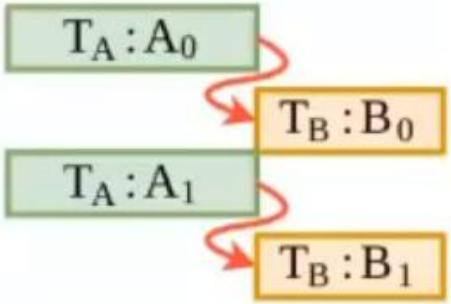
> Assumptions:
>
> - A node can start execution only after all input dependencies are satisfied
> - A node has a (static, unchanging) delay after which the outputs can be considered stable and ready

Gantt charts and Firing sequences



Firing sequence:

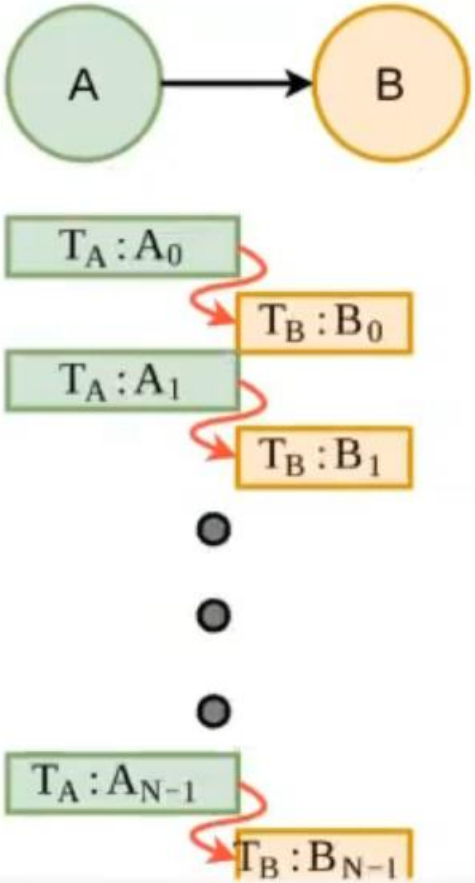
$$AB$$



Firing sequence:

$$AABB \Rightarrow A_0A_1B_0B_1$$

Gantt charts and Firing sequences



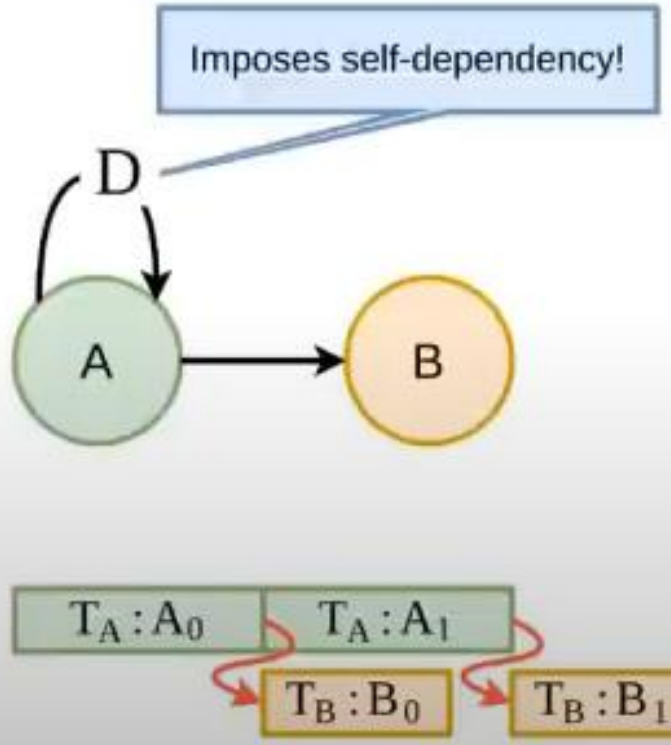
Firing sequence:

$$AA \ldots ABB \ldots B$$

$$\Rightarrow$$

$$A_0 A_1 \ldots A_{N-1} B_0 B_1 \ldots B_N$$

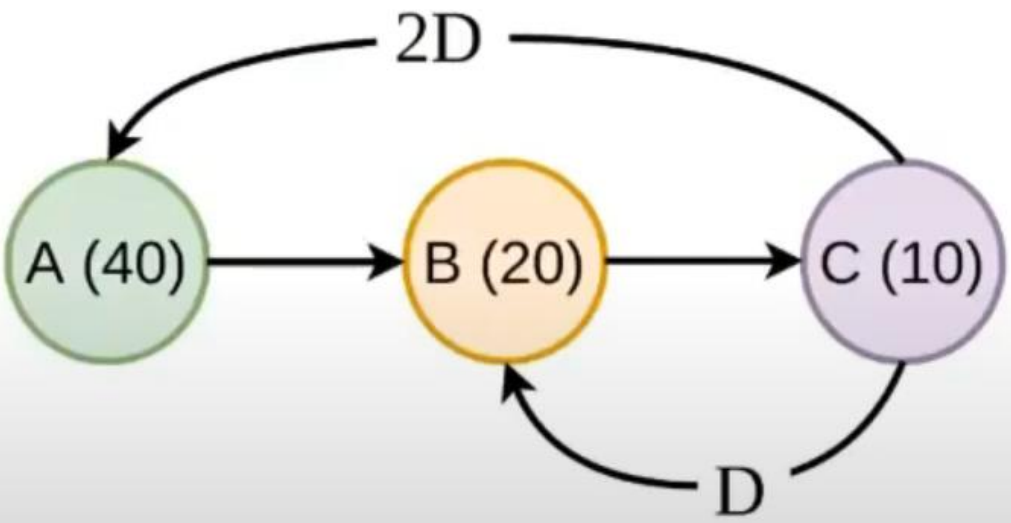
Self-dependency



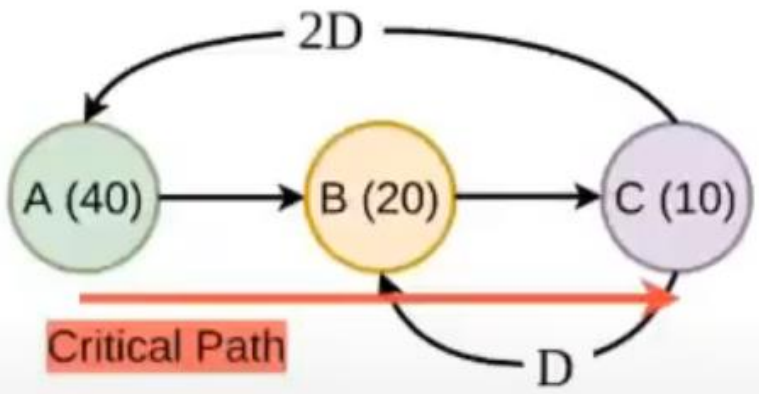
Firing sequence:

$$AABB \Rightarrow A_0 A_1 B_0 B_1$$

General Iterative DFGs

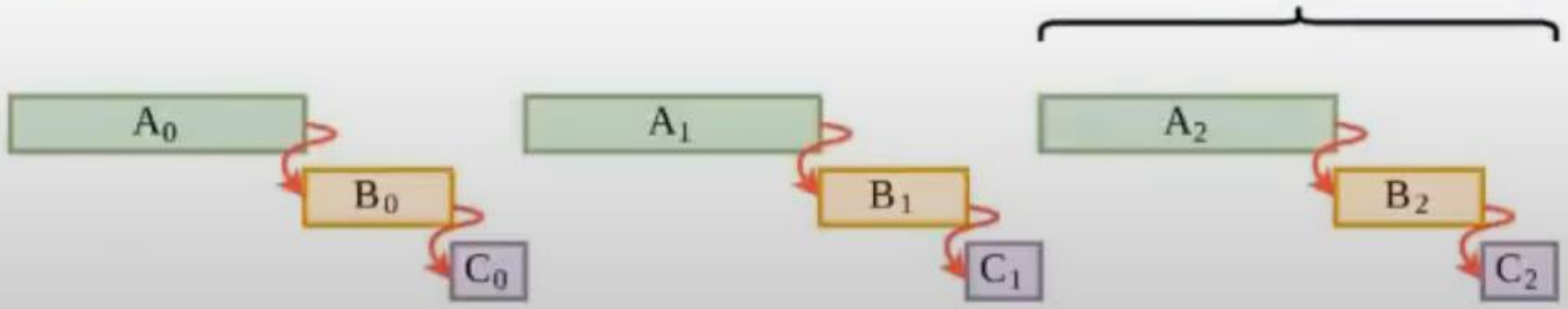


Critical path

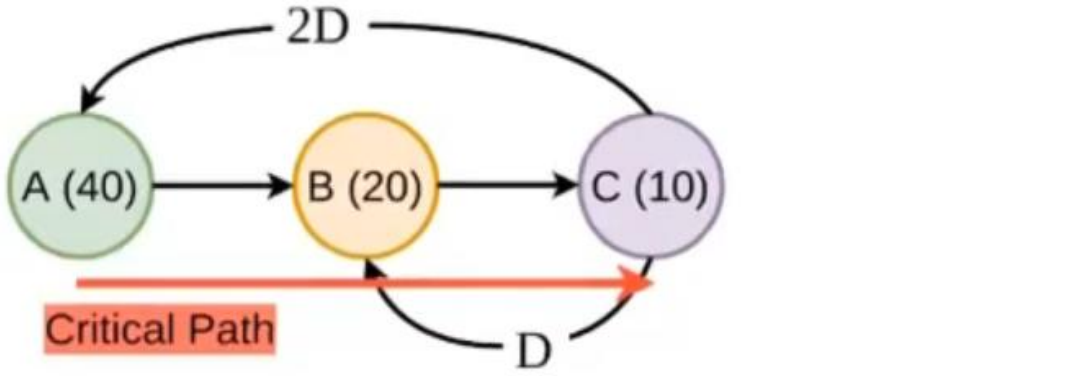


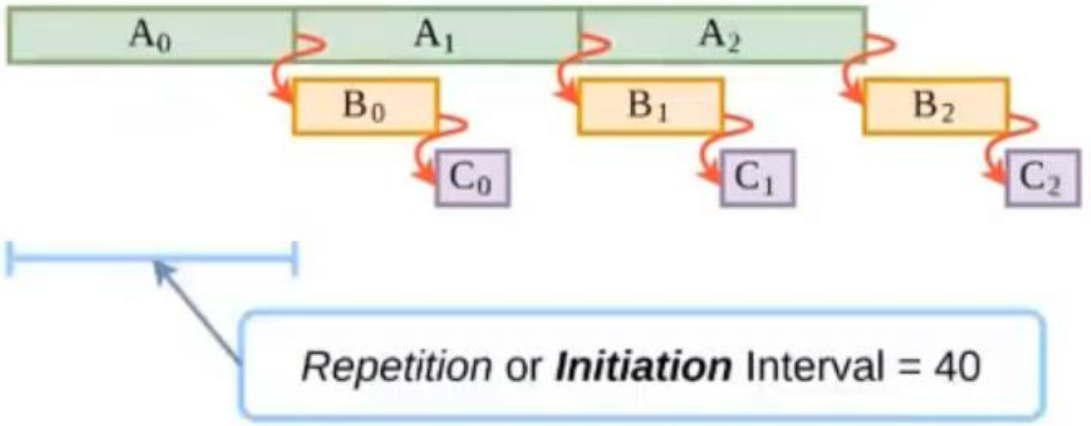
Basic block:
1 full iteration

Critical path = 70

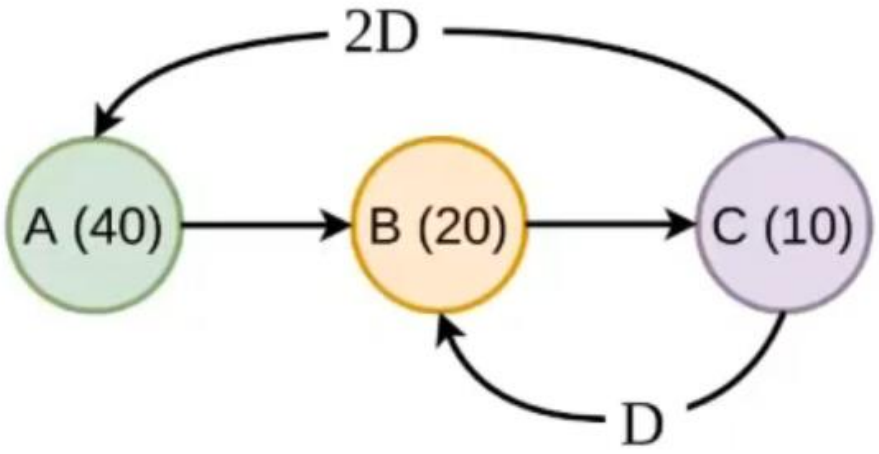


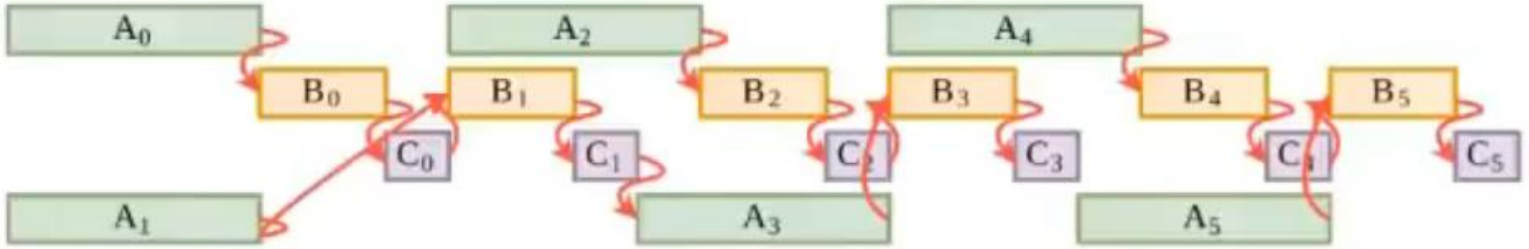
Overlapped Iteration



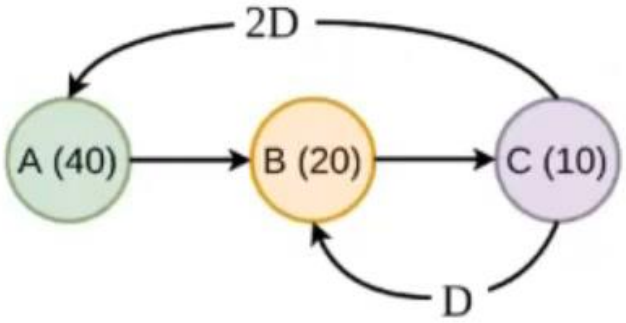


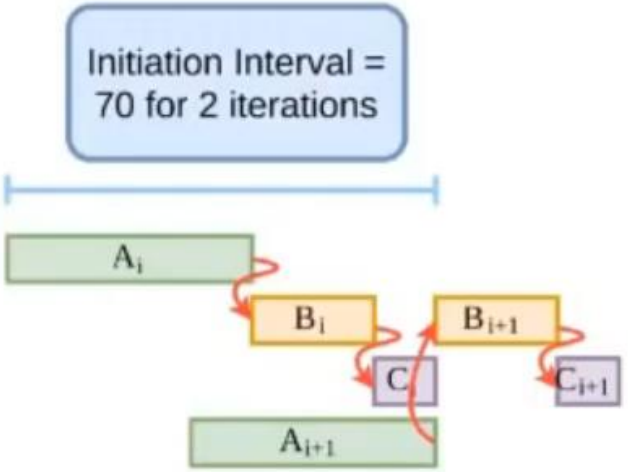
Self-timed execution

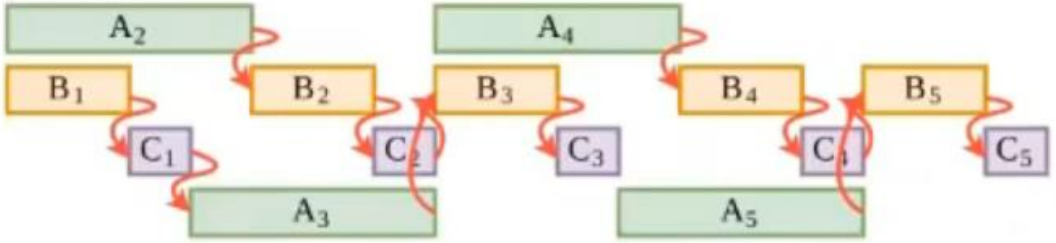




Steady State







Timing analysis

How could two instances of *A* run in parallel?

> 2 initial tokens present on *C*-*A* edge

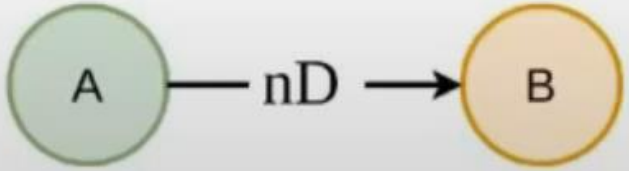
- *A2* depends on *C0*, but *A0* and *A1* do not
- *B0* depends on *A0* - critical path
- *B1* depends on *C0*, but *B0* does not

- Latency: time to finish one iteration
- Initiation interval: time to start next iteration

Iteration period

Assume T is the average iteration period: time between successive *samples* or *iterations*

$$x_B \geq x_A + d_A$$



$$x_B \geq x_A + d_A - nT$$

Arbitrary graph

$$\forall e \in E : u \to v \text{ with n delays}$$

$$x_v \geq x_u + d_u - nT$$

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$$\forall e \in E : u \to v \text{ with n delays}$$
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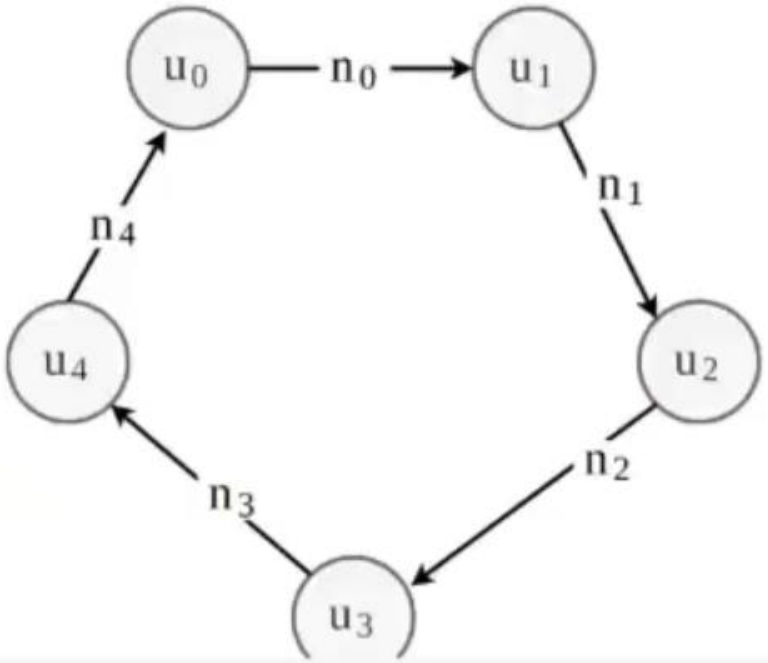

$$\begin{array}{lcl} x_1 & \geq & x_0 + d_0 - n_0 T \\ x_2 & \geq & x_1 + d_1 - n_1 T \\ x_3 & \geq & x_2 + d_2 - n_2 T \\ x_4 & \geq & x_3 + d_3 - n_3 T \\ x_0 & \geq & x_4 + d_4 - n_4 T \\ \hline 0 & \geq & \sum d_i - T \times \sum n_i \end{array}$$

$$T \geq \frac{\sum d_i}{\sum n_i}$$

Iteration Period Bound

- Property of dataflow graph representing the algorithm
  - Depends on how accurately the DFG captures the function!
- Property of the hardware technology choice
- Fundamental limitation: cannot be easily modified
  - Lookahead *etc* work in specific cases where the math is OK

Any Question…

Thank you