Common Execution Models for Dataflow

- Concurrent processes at one per actor
- Demand- or data-driven interpreters
- Compiled sequential process
- Communicating compiled sequential processes with finite buffers and handshaking.

The first two satisfy neither of the objectives, and the second two will not always satisfy the constraint.

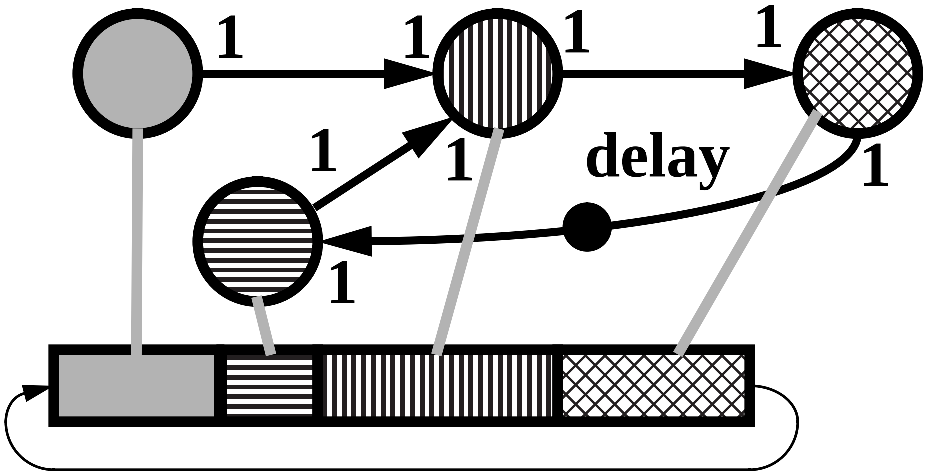
Types of Schedulers

- Static: A finite list of firings is executed forever. The firings in the list must bring the graph back to its original state.

- Quasi-Static: A finite list of *annotated* firings is executed forever. The annotations are Boolean conditions under which each firing should occur.

- Dynamic: A run-time scheduler determines which actor fires next.

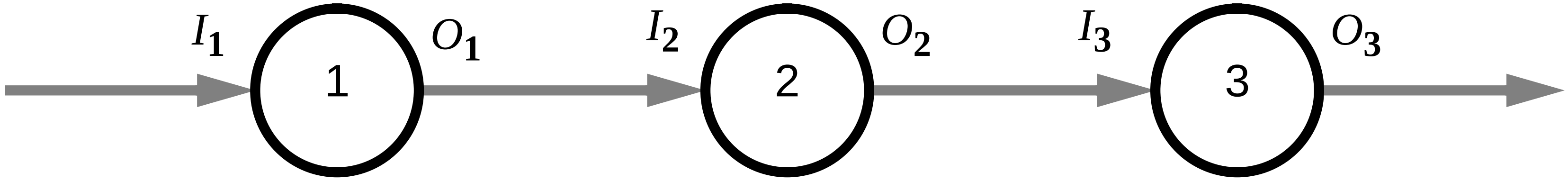
Example — Static Scheduling



Homogeneous synchronous dataflow, where every directed loop must have at least one delay, is particularly easy: Treat delays as initial tokens, and find a firing sequence that fires each actor once and obeys the firing rules. That firing sequence can be repeated indefinitely.

This idea generalizes easily to SDF.

Scheduling Synchronous Dataflow (SDF)



Balance equations:

$$r_1 O_1 = r_2 I_2$$

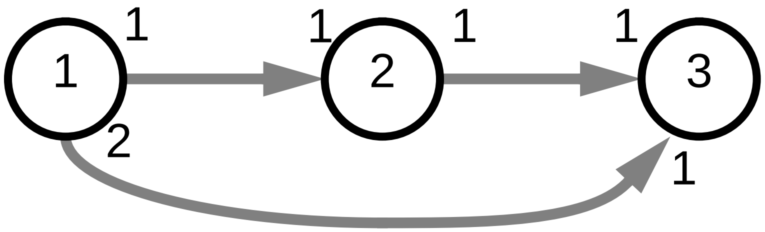
$$r_2 O_2 = r_3 I_3$$

Solve for the smallest integers r_i.

Then schedule according to data dependencies until repetitions r_i have been met for all actors or the graph halts.

Bounded Memory for SDF

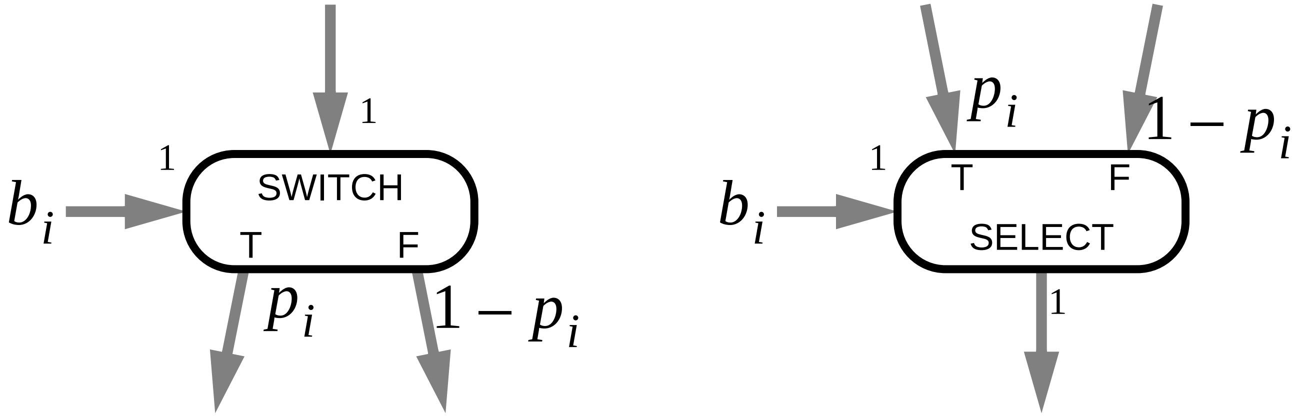
The balance equations have no solution if the graph is *inconsistent*. For example:



Bounded memory execution is not possible in this case.
Use dynamic scheduling.

For consistent SDF graphs with enough delays, all scheduling objectives and constraints can be satisfied, and the solution will always be a least fixed point.

Balance Equations Generalize to Boolean Dataflow



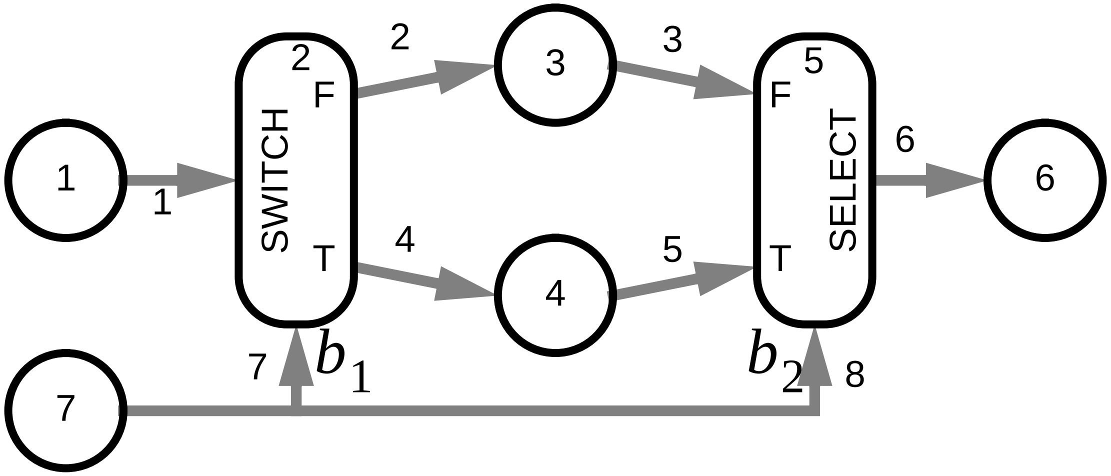
The variable p_i is a symbolic placeholder for an unknown.

The balance equations are solved symbolically.

- Consistency becomes necessary *but not sufficient* for bounded memory (it becomes undecidable whether the graph can be executed in bounded memory).
- Whether the graph halts also becomes undecidable.

Example

Conditional construct:



The following sequence of conditional firings constitutes a complete cycle that can be repeated forever:

$$S = \{1, 7, 2, (1 - b_1)3, (b_1)4, 5, 6\}$$