EN2911X: Reconfigurable Computing
Lecture 11: Design Flow: Scheduling (3)

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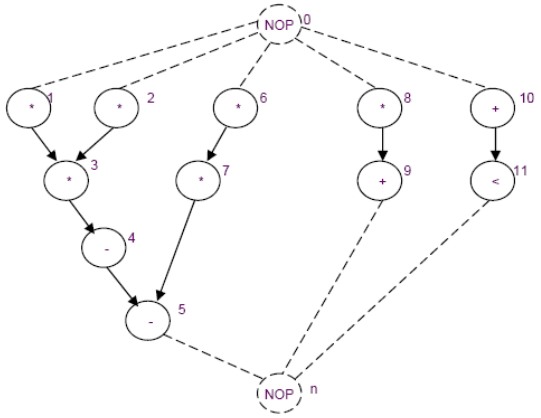
Behavioral synthesis

Given:

- a sequencing graph (data/control flow graph) that is constructed from the circuit behavioral circuit specification after code optimizations
- a set of functional resources (multipliers, adders, …, etc) each characterized in terms of area, delay and power
- a set of constraint (on circuit delay, area and power)



Synthesizing the output circuit consists of two stages:

(1) Place operations in time (scheduling) and space (bind them to resources)

(2) Determine the detailed connection of the data path the control unit

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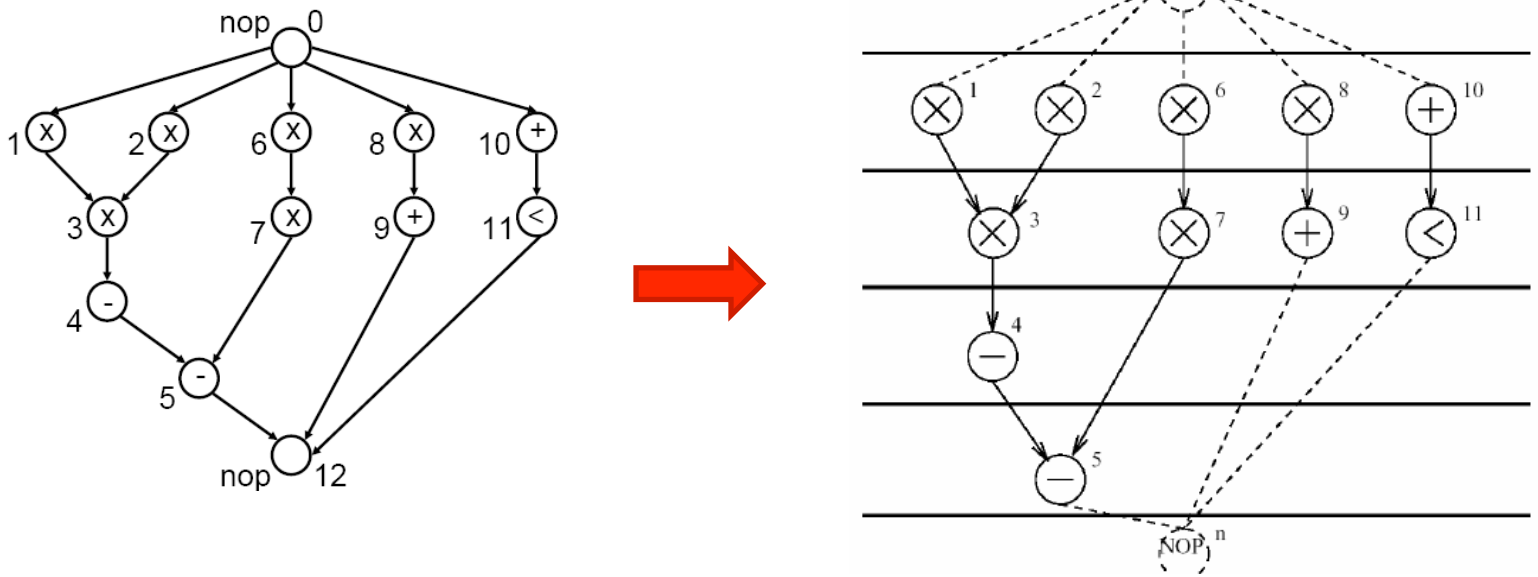
Scheduling (temporal assignment)

- *Scheduling* is the task of determining the start times of all operations, subject to the precedence constraints specified by the sequencing graph



- The *latency* of the sequencing graph is the difference between the start time of the sink and the start time of the source

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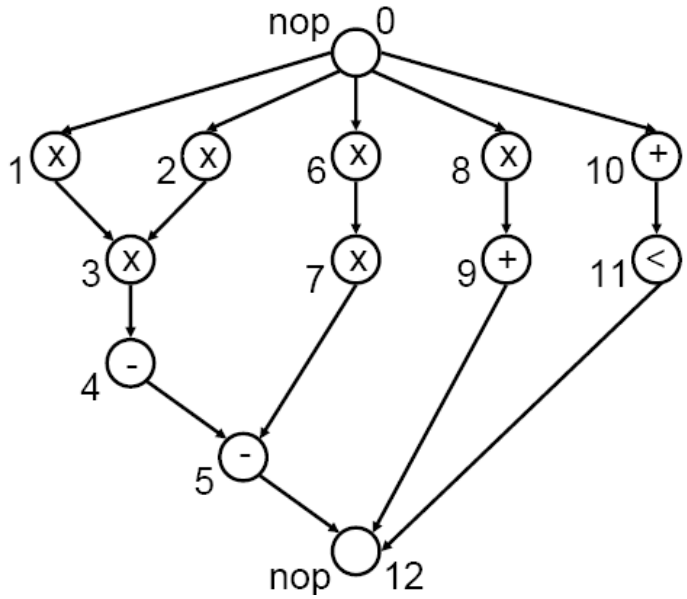
Scheduling to minimize the latency

Consider the following differential equation integrator

$$y''+3xy'+3y=0$$

$$x(0)=x;\ y(0)=y;\ y'(0)=u$$

```
read (x, y, u, dx, a);
do {
  xl = x + dx;
  ul = u – (3*x*u*dx) – (3*y*dx);
  yl = y + u*dx;
  c = xl < a;
  x = x1; u = u; y = yl;
} while (c);
write(y);
```



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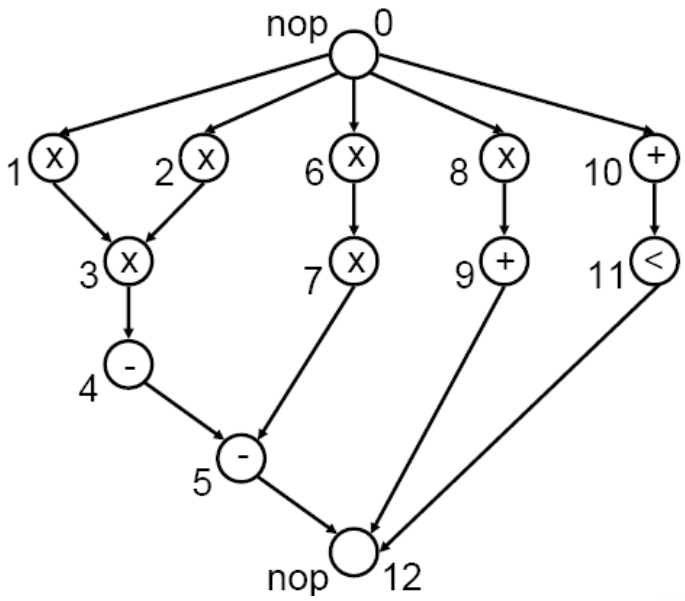
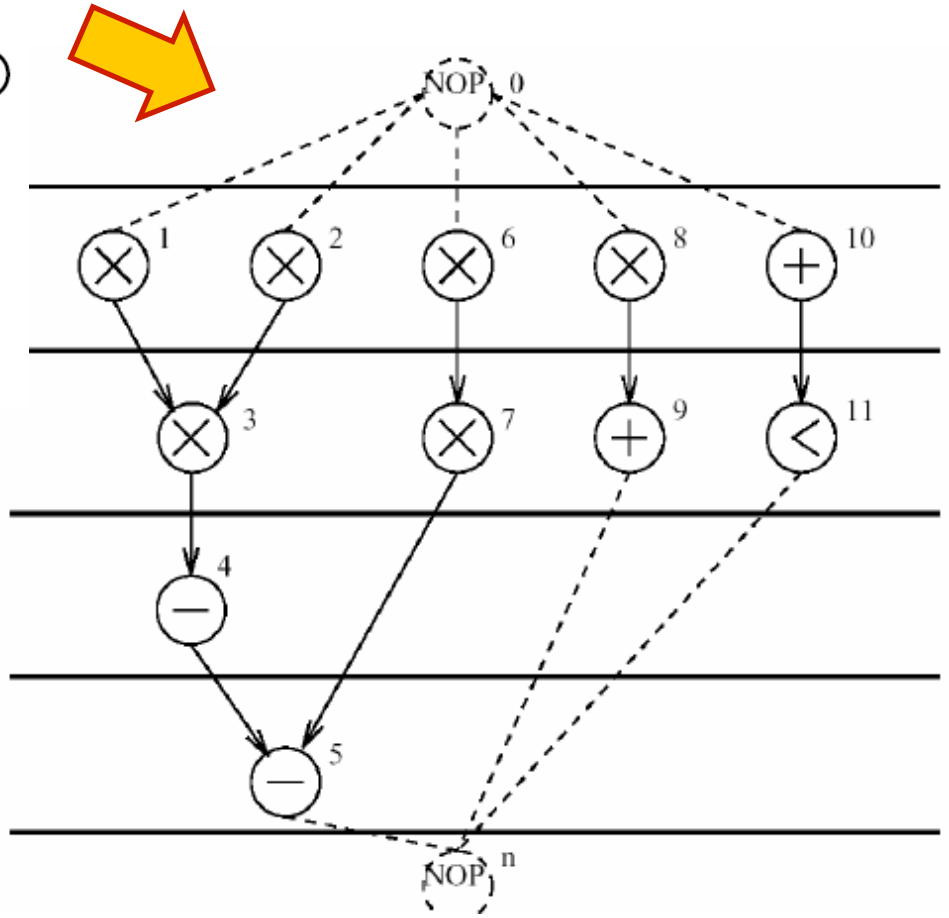
ASAP scheduling for minimum latency



Assuming all operations to have 1 unit delay, what is the latency here?



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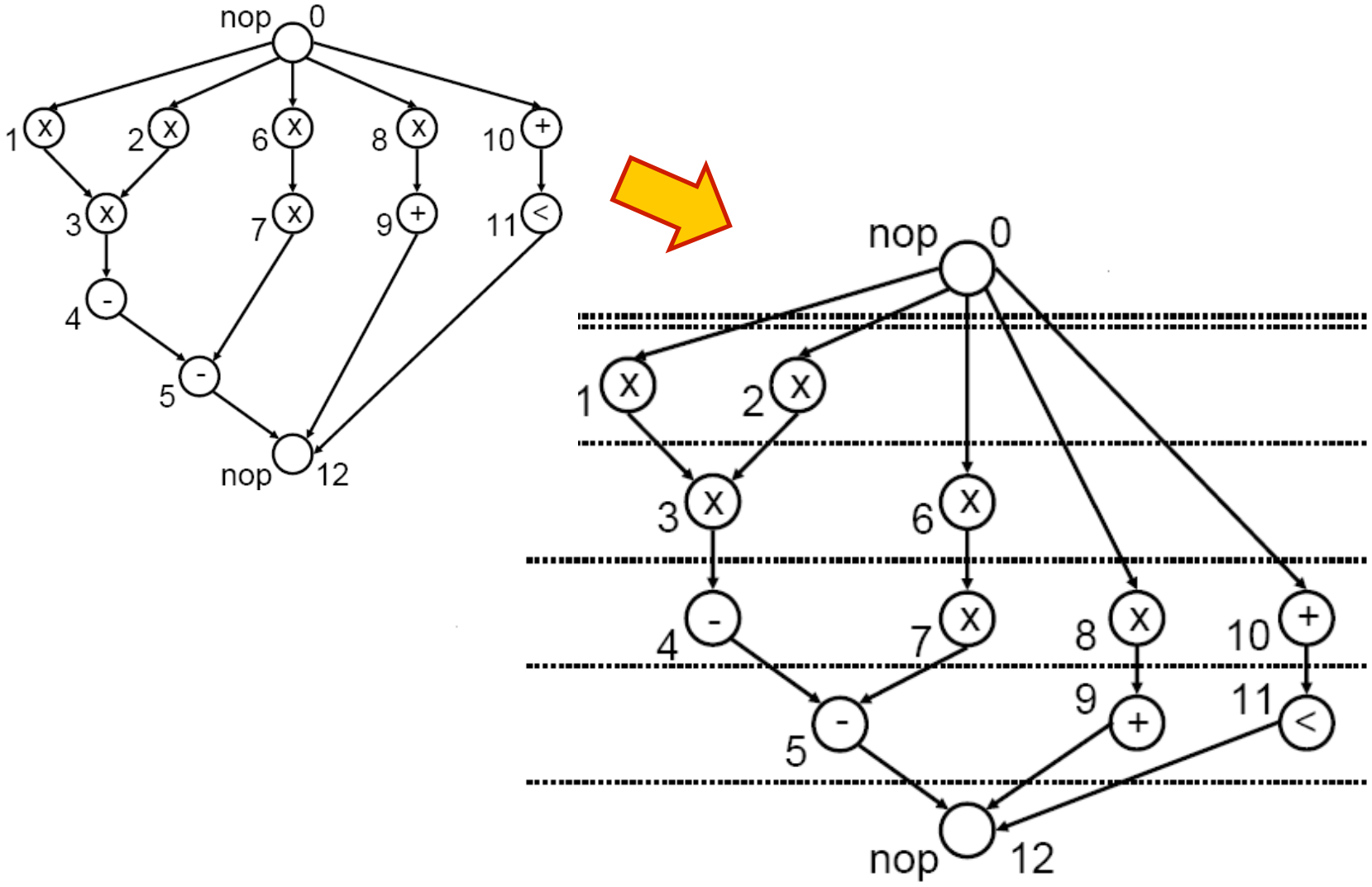
ASAP scheduling algorithm

```
ASAP ( Gs(V,E) ) {
        Schedule v0 by setting t0 = 1;
        repeat {
                Select a vertex vi whose predecessors are all scheduled;
                Schedule vi by setting  ti = max_{j:(vj,vi) ∈ E}  tj + dj ;
        }
        until (vn is scheduled);
        return (t );
}
```

ALAP scheduling to meet latency constraint



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ALAP scheduling algorithm

ALAP ($G_s(V,E), \overline{\lambda}$) {

Schedule v_n by setting $t_n = \overline{\lambda} + 1$;

repeat {

Select a vertex v_i whose successors are all scheduled;

Schedule v_i by setting $t_i = \min_{j:(v_i,v_j) \in E} t_j - d_i$;

}

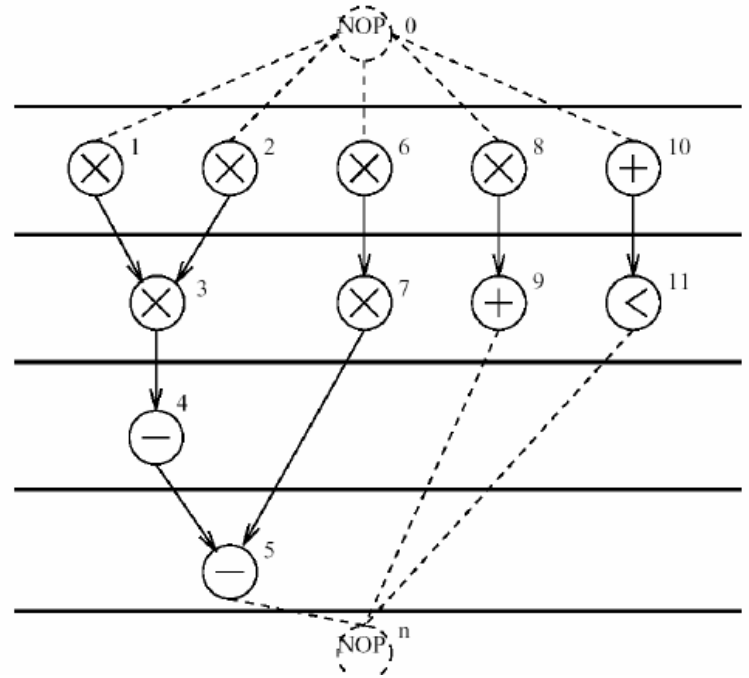
until (v_0 is scheduled);

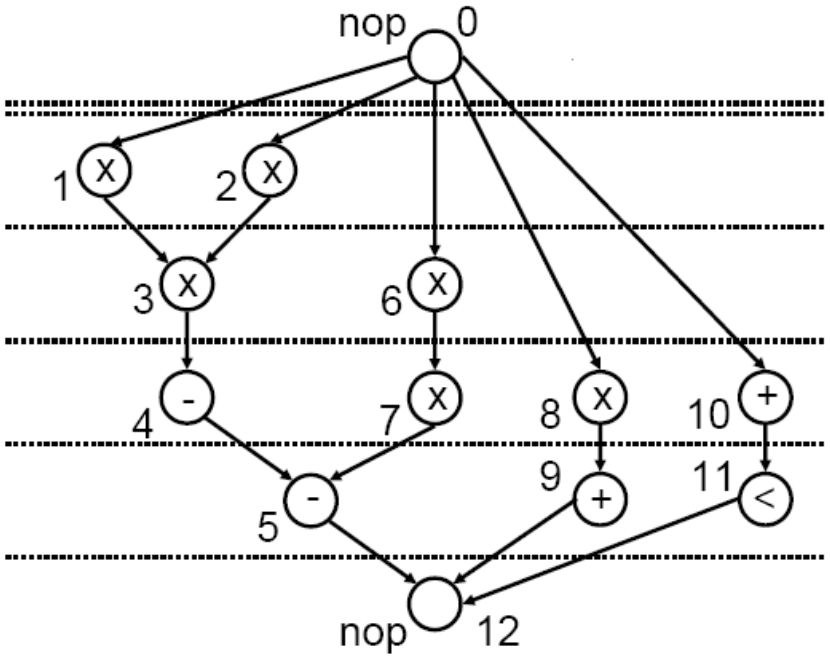
return (t);

}

Operation mobility

- The *mobility* of an operation corresponds to the difference of the start time computed between the ALAP and ASAP algorithms
- Mobility measure the freedom we have in scheduling an operation to meet the timing schedule





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