System Representation: Algorithms and Signal Flow Graphs

It is common to represent digital system signal processing routines as a visual **signal flow graphs**.

We use a simple *equation* relation to describe the **algorithm**.

Three Basic Building Blocks

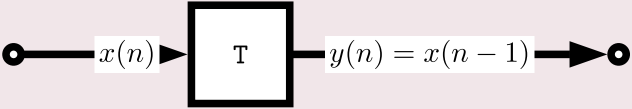
We will need to consider *three* processes:

- Delay
- Multiplication
- Summation

Signal Flow Graphs: Delay

Delay

- We represent a delay of **one sampling interval** by a block with a T **label**:



- We describe the algorithm via the equation: $y(n) = x(n-1)$

Signal Flow Graphs: Delay Example

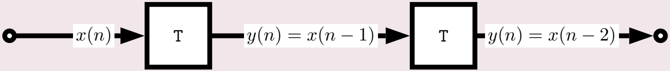
A Delay of 2 Samples

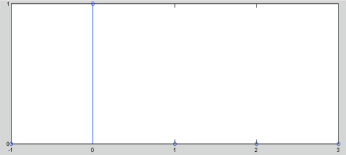
A delay of the input signal by **two** sampling intervals:

- We can describe the **algorithm** by:

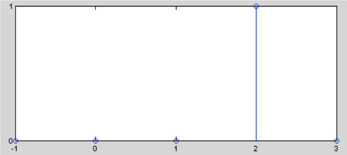
$$\mathbf{y(n) = x(n-2)}$$

- We can use the block diagram to represent the **signal flow graph** as:





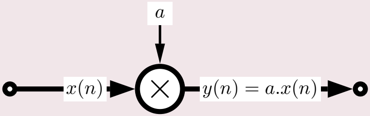
$x(n)$



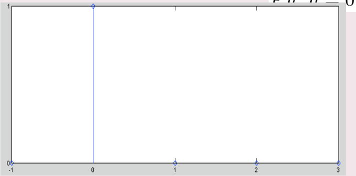
$y(n) = x(n-2)$

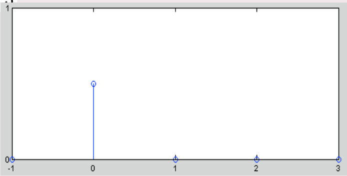
Multiplication

- We represent a multiplication or weighting of the input signal by **a circle with a $\times$ label** .
- We describe the algorithm via the equation: $\mathbf{y(n) = a.x(n)}$



e.g. $a = 0.5$





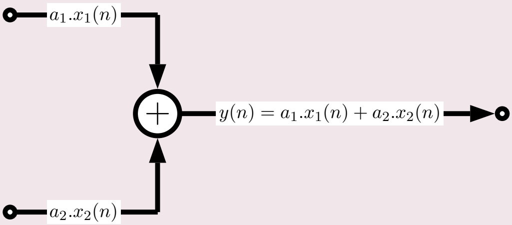
$x(n)$ $\qquad$ $y(n) = 0.5x(n)$

Signal Flow Graphs: Addition

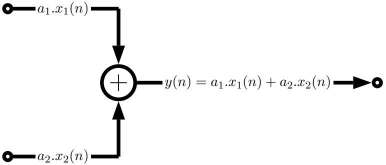
Addition

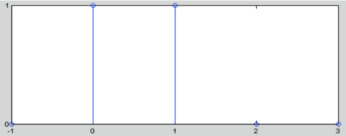
- We represent a addition of two input signal by **a circle with a + label** .
- We describe the algorithm via the equation:

$$\mathbf{y(n) = a_1.x_1(n) + a_2.x_2(n)}$$

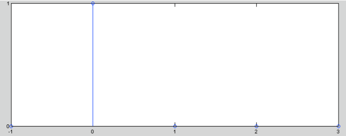


In the example, set $a_1 = a_2 = 1$:

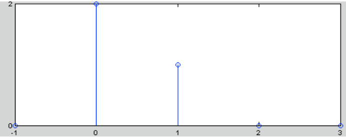




$x_1(n)$



$x_2(n)$



$y(n) = x_1(n) + x_2(n)$

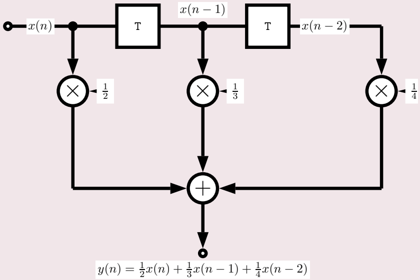
Signal Flow Graphs: Complete Example

All Three Processes Together

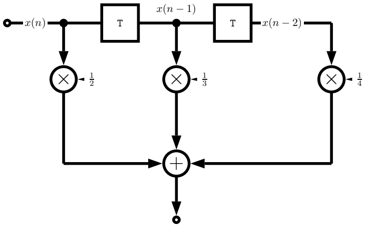
We can combine all above algorithms to build up more complex algorithms:

$$\mathbf{y(n) = \frac{1}{2}x(n) + \frac{1}{3}x(n-1) + \frac{1}{4}x(n-2)}$$

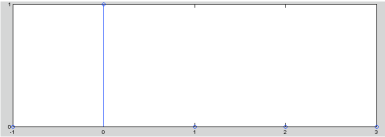
- This has the following signal flow graph:



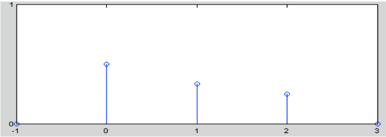
Signal Flow Graphs: Complete Example Impulse Response



$y(n) = \frac{1}{2}x(n) + \frac{1}{3}x(n-1) + \frac{1}{4}x(n-2)$



$x(n)$



$$y(n) = \frac{1}{2}x(n) + \frac{1}{3}x(n-1) + \frac{1}{4}x(n-2)$$