EE 477 Digital Signal Processing

5b
Implementing FIR Systems

FIR Computation

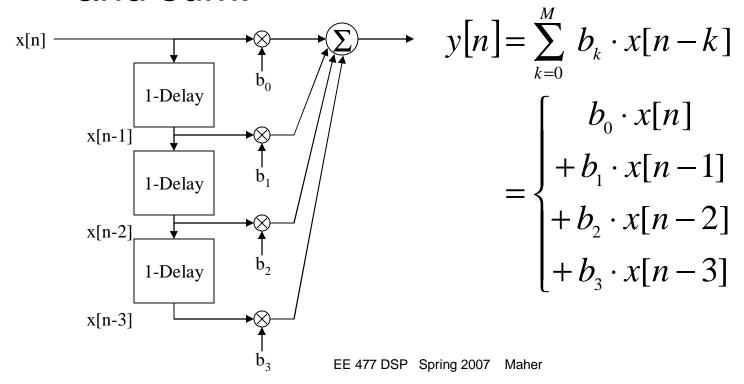
The general definition of FIR:

$$y[n] = \sum_{k=0}^{M} b_k \cdot x[n-k]$$

- Requires
 - Delayed values of input x[n]
 - Multiply coefficients b_k
 - Sum up partial products

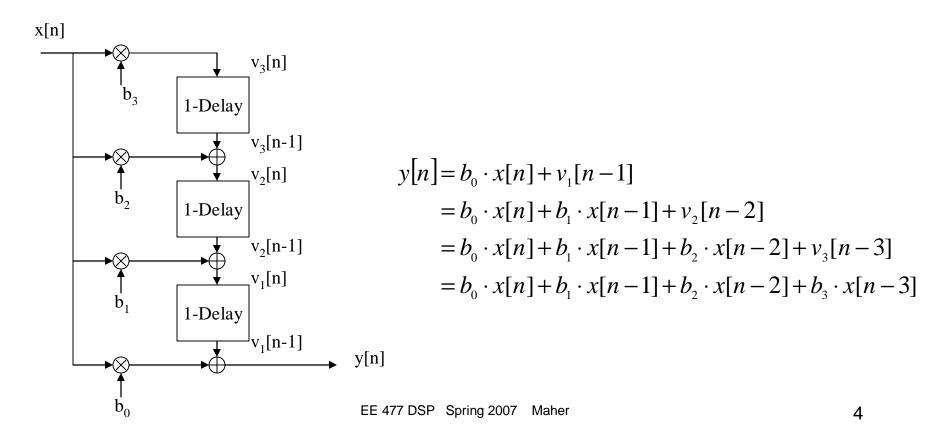
FIR Signal Flow Diagram

 Use unit delay elements, multipliers, and sum:



Another Flow Diagram

Analyze to show the same result:



Time Invariant

 A time invariant system: delaying the input simply delays the output.

• If *f*() is LTI, then:

if
$$y[n] = f(x[n]), \rightarrow y[n-n_0] = f(x[n-n_0])$$

Linearity

 A linear system: scaling and summing various inputs simply scales and sums the corresponding outputs.

• Linearity implies *superposition*:

if
$$y_1[n] = f(x_1[n])$$
 and $y_2[n] = f(x_2[n])$, then $f(\alpha \cdot x_1[n] + \beta \cdot x_2[n]) = \alpha \cdot y_1[n] + \beta \cdot y_2[n]$

LTI: Linear Time Invariant

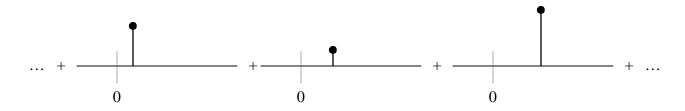
- LTI systems are an important class of systems
- Not all useful systems are LTI
- If we know a system is LTI, then we know that it can be fully described by its *unit sample response*, since we can represent the output as a delayed and scaled sum (time shift and superposition).

Convolution and δ[n]

Recall that:

$$x[n] = \sum_{\text{all } l} x[l] \cdot \delta[n-l]$$

Expresses x[n] as a sum of shifted and scaled impulses:



Convolution (cont.)

 So, applying the shifted and scaled impulses to an LTI system means the output is a set of shifted and scaled impulse responses!

$$y[n] = \sum_{\text{all } l} x[l] \cdot h[n-l]$$

All LTI systems can be represented this way.

Convolution (cont.)

- Convolution operation is associative, commutative, and distributive
- Cascaded (sequential) LTI systems imply convolution sequence:

